



Young Stars with SALT*

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Abstract

We present a spectroscopic and kinematic analysis of 79 nearby M dwarfs in 77 systems. All of these dwarfs are low-proper-motion southern hemisphere objects and were identified in a nearby star survey with a demonstrated sensitivity to young stars. Using low-resolution optical spectroscopy from the Red Side Spectrograph on the South African Large Telescope, we have determined radial velocities, H-alpha, lithium 6708 Å, and potassium 7699 Å equivalent widths linked to age and activity, and spectral types for all of our targets. Combined with astrometric information from literature sources, we identify 44 young stars. Eighteen are previously known members of moving groups within 100 pc of the Sun. Twelve are new members, including one member of the TW Hydra moving group, one member of the 32 Orionis moving group, 9 members of Tucana-Horologium, one member of Argus, and two new members of AB Doradus. We also find 14 young star systems that are not members of any known groups. The remaining 33 star systems do not appear to be young. This appears to be evidence of a new population of nearby young stars not related to the known nearby young moving groups.

Key words: open clusters and associations: general – solar neighborhood – stars: low-mass – stars: pre-main sequence – techniques: spectroscopic

Supporting material: machine-readable tables

1. Introduction

The nearby young moving groups (NYMGs), loose associations of nearby stars between 5 (ε Cha, Murphy et al. 2013) and 525 Myr old (χ¹ For, Pöhl & Paunzen 2010), are thought to be remnants of small-scale star formation in the nearby Sco-Cen star-forming region and represent the closest assemblages of pre-main-sequence stars and young planetary systems to the Sun. They are valuable targets for studying the formation of low-mass stars, brown dwarfs, and planetary systems because their proximity makes it easier to study fainter objects and companions at smaller separations.

A number of investigators have dedicated time to large-scale surveys for members of the NYMGs (e.g., Torres et al. 2000; Song et al. 2003; Shkolnik et al. 2009; Murphy et al. 2010; Schlieder et al. 2010; Riedel et al. 2011; Rodriguez et al. 2011, 2013; Malo et al. 2013; Gagné et al. 2014 and subsequent), and thanks to their efforts our samples of low-mass stars to study have been continually growing: we now know of over 650 M-dwarf and lower-mass members of the NYMGs, identified by spectroscopic signs of low surface gravity, age-related lithium absorption, and kinematic matches to the groups.

The question remains, however: given the success of these programs at identifying NYMG members, how many more remain to be discovered? The RECONS⁹ TINY proper MOtions (TINYMO) survey (Riedel 2012) delivered a number of new moving group members, many of which had been

published in Riedel et al. (2014). Given that the survey has already yielded 26 young stars out of the 55 that have been followed up with astrometry, it is reasonable to assume that the survey may contain many other young stars.

The TINYMO survey contains proper motions measured from the SuperCOSMOS Sky Survey (Hambly et al. 2001b), but these are not sufficient to identify new nearby young stars. A study of moving group identification codes (Riedel et al. 2016) demonstrates that it is impossible to be certain about memberships in a moving group based on proper motions alone; the addition of either radial velocity (RV) or parallax measurements (preferably both) dramatically increases the quality of kinematic membership assignments.

Even so, kinematic memberships are only part of the puzzle: motion, no matter how well matched to the moving group's space velocity, is no guarantee the object is actually a young star of the appropriate age. Spectroscopic evidence of youth in the form of measurable lithium or low-surface gravity features (weak lines of neutral potassium, sodium, and calcium; Schlieder et al. 2012) are important independent measurements of youth apart from the motion assessment.

Using the South African Large Telescope (SALT), we set out to obtain evidence for stellar youth from RVs and spectroscopic parameters for an additional sample of stars from the TINYMO survey. In Section 2, we describe the sample selection process. In Section 3 we detail the observational setup of the Red Side Spectrograph, our observational campaign, and our data reduction procedures. In Section 4, we describe the spectroscopic measurements used to determine the RVs and gravity- and activity-sensitive spectral line measurements examined in Section 5, and we discuss the individual young stars in more detail in Section 6.

* Based on observations made with the Southern African Large Telescope (SALT).

⁹ Research Consortium On Nearby Stars, <http://www.recons.org>.

2. Sample

The sample of stars was drawn from the TINYMO survey (Riedel 2012). In that survey, nearby low-proper-motion M dwarfs in the southern hemisphere were identified in the SuperCOSMOS Science Archive (Hambly et al. 2001b). To be sensitive to stars with proper motions less than $0''.18 \text{ yr}^{-1}$ all the way down to objects with zero proper motion, an SQL query extracted stars using an upper limit on their motion between the photographic plates. Photometric distance relations calibrated to the SuperCOSMOS plate photometry (Hambly et al. 2004) were used to identify stars within 25 pc.

The excess luminosity of giant stars makes them appear much closer than they actually are, so a color-color cut was constructed using $v^{10}-K^{11}$ versus $J-K$ color to filter out giants. This exploits a property of the $J-K$ color, in that when it is plotted against $V-K$ (or any other optical band $-K$), the locus of giant stars separates from main sequence dwarfs over the approximate spectral type range M1–M6 (Riedel 2012). Consequently, most of the stars in the survey and this paper are of those spectral types, and most (though not all) of the targets have SuperCOSMOS proper motions less than $0''.18 \text{ yr}^{-1}$. Further searches of catalogs like the General Catalog of Variable Stars (Samus et al. 2012) and Catalog of Galactic Carbon Stars (Alksnis et al. 2001), low-resolution red optical spectroscopy collected at the Lowell Observatory 1.8 m and CTIO 1.5 m, and quality cuts on the photometric distance estimates reduced the sample of stars potentially within 25 pc to 651 objects.

As noted in Riedel (2012), these selection criteria biased the sample toward detecting young stars for two major reasons. First, the space velocities of the NYMGs are clustered around the local standard of rest and thus their members fall within the proper motion selection criteria. Second, young M dwarfs are overluminous, which means that the photometric distance relations identify them as being closer than they really are, and they preferentially scatter into the 25 parsec sample.

In Riedel (2012) and the subsequent work outlined in Riedel et al. (2014), trigonometric parallaxes and spectroscopy were obtained for a subset of identified low-proper-motion M dwarfs whose photometric distances were estimated to place them within 15 pc of the Sun, with preference to stars exhibiting X-ray emission (from the *ROSAT* All-Sky Survey) as a sign of coronal activity.

In this paper, we present red optical spectroscopic observations of 79 stars from the TINYMO survey selection of 651 potential nearby M dwarfs regardless of activity level. The targets are bright M dwarfs published in Riedel et al. (2014) without RVs (as of 2013 when observations took place; several RVs were published afterward), and TINYMO M dwarfs that have not been studied before. Targets were prioritized by their SuperCOSMOS plate I_{59} magnitudes. They cover a photographic plate magnitude range of $I_{59} = 9.12$ (NLTT 47004AB) to $I_{59} = 10.85$ (SCR 1316-0858). As these are the brightest targets, this sample is expected to be biased toward closer stars, binaries, and extremely young stars. Together with Riedel et al. (2014), 100 stars from the TINYMO sample have been followed up.

We have chosen to replace the astrometry and photometry from the Hambly et al. (2001b) SuperCOSMOS catalog with more recent and precise CCD-based measurements. SuperCOSMOS's astrometry is relative, not absolute, and contains proper motions forced to zero average on a per-photographic-field basis, which we have replaced with absolute ICRS-grid positions and proper motions from UCAC4 (Zacharias et al. 2013), or PPMXL (Roeser et al. 2010) where UCAC4 motions were not available. SuperCOSMOS's photometry, though internally consistent, is photographic plate measurements in blue, red, and infrared (Hambly et al. 2001a); thus, we have elected to use Johnson *V* CCD photometry from the AAVSO Photometric All-Sky Survey (APASS) Data Release 9 (Henden et al. 2016) and *K* near-infrared photometry from the Two-Micron All-Sky Survey (2MASS, Cutri et al. 2003). The adopted literature data are collected in Table 1.

3. Observations

The SALT is an 11 m telescope hosted at the South African Astronomical Observatory in Sutherland, South Africa. It is based on the design of the McDonald Observatory Hobby-Eberly Telescope (Buckley et al. 2006) and shares the segmented mirror and fixed-altitude design of that telescope, yielding an effective mirror diameter of 9.2 m. The large collecting area and advantageous position in the southern hemisphere (where most of the NYMGs are concentrated) make SALT an efficient and effective means of collecting high-SNR low-resolution spectra of young M dwarfs even under bad weather conditions. It was thus possible to schedule usable observations at all times despite SALT's fixed altitude and the associated maximum tracking time requirements for objects at mid-southern declinations.

We have obtained low-resolution optical spectroscopy from the SALT telescope and the Robert Stoble Spectrograph (RSS, Kobulnicky et al. 2003), which provides optical spectroscopy between 3200 and 9000 Å with a resolving power of up to 6000, depending on slit width.

Observations were conducted in semesters 2013A and 2013B, utilizing bad weather time; on many occasions only a single star was observed each night. At all times, the PG1800 filter was used with a 1'' slit and the PC04600 grating at an angle of $40^\circ.25$. In this mode, RSS delivers spectra covering 6500–7800 Å with a resolving power of $R = 5000$, covering the H α 6563 Å line, the lithium 6708 Å doublet, and the potassium 7699 Å line. The RSS chip is split into three equal segments, which can be reduced separately; in this way, the chips cover roughly 6500–6900 Å, 6950–7350 Å, and 7400–7800 Å. During the 2013A semester, a Neon arc lamp was used; in 2013B, this was changed to Xenon to obtain more evenly spaced lines.

Two spectra were taken per visit in a 2×2 binning mode with slow readout and with exposure times calculated for 5'' seeing conditions (in practice, the seeing was never that bad). With these conditions and bright targets (exposures were never longer than 620 s), signal-to-noise ratios of over 100 were generally reached.

In total, there are 165 spectra of the 79 stars: SCR 2237-2622 was only observed once, two stars (SCR 1816-6305, 2MASS 2004-3356) were observed three times, three stars (2MASS 0510-2340B, 2MASS 1207-3247, SCR 1842-5554A) were observed four times, and the remainder were observed twice. Twelve spectra of telluric standard stars also were taken.

¹⁰ The average of the SuperCOSMOS B_J and second epoch R filter is used as a surrogate V magnitude.

¹¹ Throughout this paper, K is the 2MASS K_s filter.

Table 1
Previously Published Astrometry and Photometry

Name	R.A. (J2000 E2000)	Decl. (J2000 E2000)	Pos. References	$\mu_{\text{R.A.}}^a$ ("yr ⁻¹)	$\mu_{\text{decl.}}$	μ References	π		V		K	
							(mas)	References	(mag)	References	(mag)	References
SCR 0017-6645	004.348112	-66.753424	1	102.9 ± 1.0	-15.0 ± 1.0	1	25.61 ± 1.73	3	12.49 ± 0.04	7	7.70 ± 0.02	1
GJ 2006A	006.959305	-32.551783	1	99.2 ± 1.3	-61.3 ± 2.6	1	30.97 ± 1.76	3	12.82 ± 0.06	7	8.01 ± 0.03	1
GJ 2006B	006.959810	-32.556723	1	117.2 ± 4.1	-31.5 ± 5.8	1	30.97 ± 1.76	3	13.14 ± 0.04	7	8.12 ± 0.03	1
HIP 3556	011.367317	-51.626090	1	100.3 ± 1.3	-57.1 ± 0.9	1	24.78 ± 2.65	4	11.97 ± 0.04	7	7.62 ± 0.03	1
SCR 0106-6346	016.594516	-63.777545	1	150.3 ± 1.3	65.0 ± 1.3	1	...	...	13.40 ± 0.04	7	8.39 ± 0.03	1
[PS78] 190	020.683483	-25.785484	1	50.3 ± 1.1	6.1 ± 1.5	1	...	...	13.01 ± 0.05	7	8.28 ± 0.03	1
BAR 161-12	023.808013	-07.214303	1	93.0 ± 1.7	-48.0 ± 2.2	1	33.70 ± 0.26	5	13.43 ± 0.04	7	8.08 ± 0.03	1
GIC 138	023.985392	-13.429697	1	119.5 ± 2.5	-21.5 ± 3.2	1	...	...	13.36 ± 0.01	7	8.81 ± 0.02	1
L 173-39	027.108869	-56.978227	1	255.6 ± 8.0	-35.0 ± 8.0	1	...	...	11.72 ± 0.02	7	7.32 ± 0.02	1
SCR 0149-5411	027.274579	-54.199205	1	120.0 ± 1.4	-18.0 ± 1.4	1	...	...	13.15 ± 0.02	7	8.85 ± 0.02	1
SCR 0152-5950	028.076259	-59.837995	1	109.2 ± 1.8	-25.7 ± 1.8	1	...	...	12.49 ± 0.08	7	8.14 ± 0.03	1
SCR 0212-5851	033.242464	-58.855051	1	87.7 ± 1.3	-15.9 ± 1.3	1	...	...	12.92 ± 0.03	7	8.44 ± 0.02	1
SCR 0213-4654	033.375897	-46.914036	1	42.5 ± 1.0	4.9 ± 1.0	1	...	...	13.78 ± 0.07	7	8.60 ± 0.02	1
SCR 0215-0929	033.995595	-09.486749	1	96.6 ± 1.9	-46.5 ± 2.6	1	...	...	12.21 ± 0.05	7	7.55 ± 0.02	1
SCR 0220-5823	035.214147	-58.394755	1	97.3 ± 2.0	-13.0 ± 2.0	1	...	...	13.92 ± 0.01	7	8.83 ± 0.02	1
SCR 0222-6022	035.683964	-60.379890	1	137.4 ± 1.7	-13.8 ± 1.7	1	...	...	13.33 ± 0.05	7	8.10 ± 0.03	1
2MASS 0236-5203	039.215438	-52.051011	1	102.2 ± 0.8	1.2 ± 0.8	1	...	...	12.05 ± 0.09	7	7.50 ± 0.03	1
LP 886-73	039.823509	-26.821910	1	98.7 ± 2.9	-40.2 ± 1.3	1	...	...	14.33 ± 0.05	7	8.75 ± 0.02	1
SCR 0248-3404	042.219172	-34.073538	1	90.2 ± 1.4	-23.7 ± 1.4	1	...	...	13.64 ± 0.02	7	8.40 ± 0.03	1
SCR 0254-5746	043.526282	-57.776673	1	102.9 ± 1.1	7.2 ± 1.2	1	...	...	13.37 ± 0.03	7	8.83 ± 0.02	1
2MASS 0254-5108A	043.638184	-51.142059	1	92.0 ± 1.2	-11.9 ± 1.2	1	...	...	12.07 ± 0.03	7	7.79 ± 0.03	1
SCR 0256-6343	044.196132	-63.717440	1	67.4 ± 2.2	8.3 ± 5.6	1	...	...	14.23	8	9.01 ± 0.03	1
LP 831-35	047.512712	-23.691887	1	98.3 ± 1.3	-134.8 ± 1.3	1	...	...	13.49 ± 0.04	7	8.57 ± 0.03	1
2MASS 0510-2340A	077.517787	-23.678016	1	41.4 ± 2.3	-13.3 ± 1.1	1	...	...	13.04 ± 0.03	7	8.36 ± 0.02	1
2MASS 0510-2340B	077.520402	-23.670874	1	34.8 ± 2.7	-13.8 ± 1.5	1	...	...	13.29 ± 0.05	7	8.54 ± 0.02	1
SCR 0522-0606	080.669559	-06.106641	1	17.0 ± 3.2	-21.1 ± 3.3	1	...	...	14.27 ± 0.06	7	9.13 ± 0.02	1
SCR 0711-3510AB	107.996535	-35.171050	1	-27.7 ± 1.2	-57.9 ± 1.6	1	...	...	13.65 ± 0.06	7	8.79 ± 0.02	1
SCR 0844-0637	131.231937	-06.623875	2	-58.3 ± 5.3	-126.4 ± 5.3	2	...	...	13.38 ± 0.05	7	8.51 ± 0.02	1
LP 728-71	148.174075	-15.603822	1	-117.0 ± 1.2	-135.2 ± 1.3	1	...	...	13.46 ± 0.05	7	8.51 ± 0.02	1
SCR 1012-3124AB	153.037878	-31.412579	1	-74.8 ± 1.1	-9.4 ± 1.0	1	18.54 ± 1.74	3	13.42 ± 0.07	7	7.99 ± 0.03	1
TWA 3ABCD	167.616225	-37.531102	1	-105.9 ± 0.9	-17.3 ± 1.0	1	...	...	12.05 ± 0.01	7	6.77 ± 0.02	1
SCR 1121-3845	170.272849	-38.754586	1	-66.6 ± 1.5	-11.7 ± 1.5	1	15.59 ± 0.70	6	12.59 ± 0.06	7	8.05 ± 0.03	1
TWA 5ABC	172.980251	-34.607570	1	-79.6 ± 0.8	-22.6 ± 0.9	1	19.97 ± 0.70	6	11.45 ± 0.13	7	6.75 ± 0.02	1
RX 1132-3019	173.076313	-30.331070	1	-87.8 ± 1.3	-25.2 ± 1.3	1	...	...	14.41	8	8.77 ± 0.02	1
RX 1132-2651A	173.171855	-26.865554	2	-99.2 ± 6.2	-32.2 ± 6.2	2	21.28 ± 1.01	3	12.27 ± 0.02	7	7.43 ± 0.02	1
SIPS 1145-4055	176.398474	-40.932576	1	-277.2 ± 8.0	-131.9 ± 8.0	1	...	...	14.22 ± 0.04	1	8.79 ± 0.02	1
LP 851-410	179.582406	-22.683258	1	-105.1 ± 1.9	-65.1 ± 1.0	1	...	...	13.20 ± 0.05	7	8.43 ± 0.02	1
SCR 1200-1731	180.006620	-17.525233	1	-81.0 ± 1.1	-24.6 ± 1.2	1	...	...	13.83 ± 0.06	7	8.47 ± 0.03	1
2MASS 1207-3247	181.864072	-32.783402	1	-70.4 ± 1.4	-29.7 ± 1.1	1	18.55 ± 0.48	6	12.64 ± 0.04	7	7.75 ± 0.03	1
L 758-107	182.820600	-19.972708	1	-204.5 ± 2.1	-190.6 ± 3.0	1	...	...	12.62 ± 0.02	7	7.74 ± 0.02	1
SCR 1230-3300	187.720947	-33.014119	1	-156.7 ± 0.8	0.0 ± 0.8	1	...	...	12.56 ± 0.03	7	8.09 ± 0.02	1
SCR 1233-3641	188.380858	-36.694691	1	-55.8 ± 0.9	-49.9 ± 0.9	1	...	...	13.44 ± 0.03	7	8.74 ± 0.02	1
SCR 1237-4021	189.301605	-40.363386	1	-63.7 ± 1.1	-29.1 ± 1.1	1	...	...	13.50 ± 0.06	7	8.52 ± 0.02	1
SCR 1238-2703	189.654646	-27.059737	2	-185.1 ± 5.1	-185.2 ± 5.1	2	...	...	12.44 ± 0.03	7	7.84 ± 0.03	1

Table 1
(Continued)

Name	R.A. (J2000 E2000)	Decl.	Pos. References	$\mu_{R.A.}^a$ ("yr ⁻¹)	$\mu_{decl.}$	μ References	π		V		K	
							(mas)	References	(mag)	References	(mag)	References
SCR 1316-0858	199.168930	-08.973762	1	-57.5 ± 4.2	-56.2 ± 7.7	1	...	...	14.57 ± 0.06	7	9.20 ± 0.02	1
SCR 1321-1052	200.484680	-10.869421	1	-66.6 ± 3.1	-50.5 ± 3.8	1	...	...	13.90 ± 0.03	7	8.62 ± 0.02	1
SCR 1421-0916	215.359374	-09.282748	1	-135.3 ± 3.3	-18.5 ± 1.2	1	...	...	13.73 ± 0.07	7	8.94 ± 0.02	1
SCR 1421-0755	215.391939	-07.921291	1	-95.1 ± 2.2	-86.4 ± 1.2	1	...	...	13.61 ± 0.01	7	8.63 ± 0.02	1
SCR 1425-4113AB	216.371348	-41.225645	1	-46.8 ± 2.1	-49.2 ± 1.7	1	14.94 ± 0.96	3	12.62 ± 0.05	7	7.61 ± 0.02	1
SCR 1438-3941	219.651047	-39.685075	1	-109.8 ± 1.0	-104.5 ± 2.2	1	...	...	12.73 ± 0.01	7	8.52 ± 0.02	1
LP 914-6	220.092260	-27.878378	1	-127.9 ± 8.0	-202.2 ± 8.0	1	...	...	13.62 ± 0.01	7	8.75 ± 0.02	1
SCR 1521-2514	230.461609	-25.236576	1	-32.4 ± 1.4	-56.2 ± 2.0	1	...	...	13.38 ± 0.03	7	8.65 ± 0.02	1
SCR 1708-6936	257.036730	-69.605169	1	-54.6 ± 1.7	-81.1 ± 1.7	1	...	...	13.16 ± 0.02	7	8.20 ± 0.02	1
SCR 1816-6305	274.211919	-63.088775	1	-117.5 ± 6.1	-47.3 ± 2.0	1	...	...	12.74 ± 0.01	7	8.39 ± 0.03	1
SCR 1842-5554A	280.528984	-55.907110	1	9.7 ± 12.1	-81.2 ± 2.8	1	...	...	13.59 ± 0.14	7	8.58 ± 0.02	1
NLTT 47004AB	282.172344	-46.785495	2	196.6 ± 3.2	125.6 ± 3.2	2	...	...	11.60 ± 0.02	7	6.99 ± 0.04	1
SCR 1856-6922	284.018227	-69.366773	1	-10.8 ± 1.4	-115.6 ± 2.3	1	...	...	12.44 ± 0.04	7	7.70 ± 0.02	1
WT 625	286.334771	-54.578257	1	86.2 ± 8.0	-213.3 ± 8.0	1	...	...	13.34 ± 0.01	1	8.55 ± 0.02	1
SCR 1922-6310	290.711309	-63.182795	1	-7.9 ± 16.7	-77.5 ± 1.9	1	...	...	13.31 ± 0.06	7	8.58 ± 0.02	1
RX 1924-3442	291.145631	-34.710924	1	22.1 ± 1.8	-71.7 ± 1.8	1	...	...	14.24 ± 0.06	7	8.79 ± 0.03	1
SCR 1926-5331	291.503116	-53.524166	1	34.1 ± 2.1	-87.4 ± 2.1	1	...	...	14.03 ± 0.13	7	8.68 ± 0.02	1
SCR 1938-2416	294.653739	-24.282940	1	33.5 ± 1.8	67.6 ± 5.8	1	...	...	13.10 ± 0.03	7	8.51 ± 0.02	1
SCR 1951-4025	297.899813	-40.422480	2	40.8 ± 14.0	-186.1 ± 14.0	2	...	...	13.55 ± 0.02	7	8.71 ± 0.02	1
SCR 2004-6725A	301.038323	-67.419721	1	7.0 ± 1.3	-84.5 ± 2.4	1	...	...	13.11 ± 0.02	7	8.48 ± 0.02	1
2MASS 2004-3356	301.118608	-33.936334	1	69.4 ± 2.5	-103.3 ± 2.6	1	...	...	14.61 ± 0.05	7	9.17 ± 0.02	1
SCR 2008-3519	302.223697	-35.330161	1	49.4 ± 1.3	-76.7 ± 1.3	1	...	...	13.52 ± 0.06	7	8.32 ± 0.03	1
SCR 2010-2801AB	302.500154	-28.028066	1	40.7 ± 3.0	-62.0 ± 1.7	1	20.85 ± 1.33	3	12.98 ± 0.02	7	7.73 ± 0.03	1
L 755-19	307.181835	-11.475196	2	166.4 ± 5.2	-93.3 ± 5.2	2	53.18 ± 1.67	3	12.52 ± 0.04	7	7.50 ± 0.03	1
SCR 2107-7056	316.843702	-70.936854	1	27.5 ± 1.5	-91.6 ± 1.4	1	...	...	13.86 ± 0.08	7	8.90 ± 0.02	1
SCR 2107-1304	316.903307	-13.082831	1	59.4 ± 1.3	-86.0 ± 3.0	1	...	...	12.64 ± 0.08	7	7.84 ± 0.03	1
LEHPM 1-4147	323.717454	-63.018961	2	105.9 ± 14.0	-134.9 ± 14.0	2	...	...	13.47 ± 0.04	7	8.74 ± 0.03	1
SCR 2204-0711	331.165971	-07.192684	1	-3.1 ± 1.3	-4.2 ± 1.4	1	...	...	12.27 ± 0.21	7	-8.49 ± 0.02	1
SCR 2237-2622	339.312287	-26.375884	1	145.4 ± 1.5	-11.8 ± 1.5	1	...	...	13.33 ± 0.04	7	8.31 ± 0.02	1
SIPS 2258-1104	344.568493	-11.071400	1	106.8 ± 2.9	-5.9 ± 2.9	1	...	...	12.97 ± 0.05	7	8.24 ± 0.03	1
LEHPM 1-5404	345.456139	-53.285470	2	151.1 ± 16.1	-234.0 ± 16.1	2	...	...	13.11 ± 0.04	7	8.50 ± 0.02	1
SCR 2328-6802	352.240163	-68.042788	1	66.8 ± 1.9	-67.1 ± 1.7	1	...	...	13.02 ± 0.04	7	8.38 ± 0.02	1
LTT 9582	353.000790	-39.293587	2	193.4 ± 17.9	-178.4 ± 17.9	2	...	...	12.96 ± 0.07	7	8.02 ± 0.02	1
G 275-71	353.953102	-24.319238	1	106.5 ± 1.1	-120.7 ± 1.0	1	...	...	13.71 ± 0.02	7	8.77 ± 0.02	1
LEHPM 1-6053	355.099384	-40.363084	2	262.5 ± 13.3	-131.0 ± 13.3	2	...	...	12.94 ± 0.02	7	8.34 ± 0.03	1

Note. The kinematic data used by LACEwING (in Section 5) and photometric data used in our youth analysis. Literature RVs were not used even where they exist. (1) UCAC4 (includes APASS DR6 $g'r'i'BV$ and 2MASS JHK_s), Zacharias et al. (2013), (2) PPMXL, Roeser et al. (2010), (3) Riedel et al. (2014), (4) van Leeuwen (2007), (5) Shkolnik et al. (2012), (6) Weinberger et al. (2013), (7) Henden et al. (2016) (8) Zacharias et al. (2004).

^a $\mu_{R.A.}$ is actually $\mu_{R.A.\cos decl.}$ everywhere it appears.

(This table is available in machine-readable form.)

The entire observing program totaled 140,000 s (39 hr) of observing time.

Data were reduced with PyRAF and the Astropy astronomical python package (Astropy Collaboration et al. 2013), using standard IRAF long-slit reduction techniques. The individual RSS chips were treated separately to increase the accuracy of RV calibrations. The wavelength calibration error obtained by IRAF was around 0.04 Å for both xenon and neon arc lamps. Of all the flux standards observed, only Hiltner 600, observed in 2013B, was taken with sufficient signal to noise to be used in reductions.

4. Analysis

Spectral types (Table 2) were determined using the MATCHSTAR code (Riedel et al. 2014), an automated template-matching code that compares red optical spectra to RECONS K and M standard star spectra (Kirkpatrick et al. 1991; Henry et al. 1994, 2002) between 6000 Å and 9000 Å, after trimming and degrading resolution so that input and standard spectra overlap. With the prioritization of the brightest M dwarfs in the sample, it is unsurprising that most of the objects skew toward the hotter M dwarfs—M1.0V–M3.0V. The hottest star is SCR 2204-0711, K9.0Ve (though see Section 6.9); the coolest star is RX 1132-3019, M4.5Ve (Figure 1). Spectral types are given in Table 2.

4.1. Radial Velocities

RVs were measured from the SALT data using the same code developed for and used in Faherty et al. (2016). The code cross-correlates the spectrum of a star of unknown RV to one of known RV and the same spectral type. The process is repeated 1000 times, adding random Gaussian noise scaled to the per-pixel flux uncertainties of both the known and unknown star’s spectrum, in order to quantify the effect of noise on the RV measurement. The RV results of the 1000 iterations are then binned into a histogram and fit with a Gaussian to determine the mean RV and uncertainty.

As noted in Faherty et al. (2016), this cross-correlation technique still under-estimates the true uncertainties in the measured RV. To accommodate systematic errors in the data, we cross-correlate the spectra against multiple comparison stars and combine the results with a weighted standard deviation. Ideally, the comparison stars would be RV standards, but we did not observe any RV standards. Instead, we selected 13 stars with previously measured RVs with uncertainties less than 2 km s^{−1} for use as velocity comparisons. We measured the RVs of the comparison stars relative to each other (the stars marked “C” in Table 2) to demonstrate the accuracy and precision of the RVs.

Six spectral regions were considered for RV measurement (Figure 2). (1) The first chip in a 50 Å region surrounding the H α line (6530–6580 Å), (2) the first chip truncated at the atmospheric B band (6500–6840 Å), (3) the first chip with both the H α and atmospheric B band removed (6570–6840 Å), (4) the second chip covering 6980–7350 Å, (5) the third chip blueward of the atmospheric A band (7400–7580 Å), and (6), the third chip redward of the atmospheric A band. (7680–7720 Å). Initial RV measurements showing the original wavelength calibrations to both the neon and xenon lamps were insufficient for RV work. RVs of our comparison stars were typically discrepant from published values by over 10 km s^{−1}, even after being combined in weighted standard deviations.

We investigated the possibility of improving our precision by using the atmospheric A and B bands (regions shown in Figure 2) to correct the wavelength solution. The first procedure attempted involved independently cross-correlating chip 1 and chip 3 to an atmospheric template spectrum (Hinkle et al. 2003) to obtain zeropoint corrections to the wavelength solution before applying the heliocentric correction. This initial procedure produced a significant improvement in accuracy, but prevented the use of chip 2, which lacks prominent atmospheric features. A further improvement was made using the centers of the A and B bands to derive a linear correction as a function of input wavelength. This produced significantly better accuracy than the zeropoint correction, and it was found that the best results came from the second chip (region 4), where precisions of 3–6 km s^{−1} have been achieved. All RV results in Table 2 are derived from spectral region 4 with the two-point linear wavelength correction.

While it is known that spectral type matches are important to obtain precise RVs, all of our targets have very similar spectral types, and our precision appears to be low enough that those spectral morphological differences do not affect our results. Instead, we found three stars—SCR 0017-6645, SCR 0152-5950, and 2MASS 1207-3247—that produced uniformly low accuracy and low precision results in every cross-correlation. These were removed from consideration, and the RV results are based on the weighted mean and weighted standard deviation of the other 10 stars with known RVs. The RV results and uncertainties in Table 2 are thus the weighted standard deviation of between 10 and 40 measurements, depending on the number of spectra for the target. Of the 34 total stars in the sample with existing RV measurements, 24 of our measurements (70%) are within 1 σ of those reported errors and 29 (85%) are within 2 σ . Given the small number of RV crossmatches, we believe this demonstrates the accuracy of our RVs despite our relatively low precision.

4.2. Spectral Line Measurements

To evaluate spectroscopic signatures of youth, we measure equivalent widths of the H α (6563 Å) emission line, the unresolved Li (6708 Å) doublet, and the KI (7699 Å) absorption line for all 177 low-resolution optical spectra taken with SALT. To aid us in these measurements, we employ PHEW: PyHon Equivalent Widths (Alam & Douglas 2016), which is based on the Pythonic spectroscopic line analysis toolkit PySpecKit¹² (Ginsburg & Mirocha 2011).

For each case, we fit a zeroth-order baseline to the average flux of the nearby pseudocontinuum, and set the line window to be between 6550 and 6580 Å (Figure 3), 6700–6715 Å (Figure 4), and 7685–7711 Å (Figure 5) for the H α , Li, and KI lines, respectively. We then fit a Voigt profile to the spectral line in each window. (For features that do not have well-defined wings at this resolution, equivalent widths were measured with a Gaussian profile fit to the feature.) The equivalent width is then calculated by integrating the pseudocontinuum level minus the spectrum over the selected range. Uncertainties were estimated through Monte Carlo analysis of 500 iterations, for every spectrum. We have combined all measurements for a given star with a weighted mean and standard deviation, which we report in Table 6, and summarize in Table 5. For further information

¹² <http://pyspeckit.bitbucket.org/html/sphinx/index.html>

Table 2
Radial Velocities and Spectral Types

C ^a	Name	R.A. (J2000)	Decl.	Spectral Type	R.V. (km s ⁻¹)	Literature R.V.	
						(km s ⁻¹)	References
X	SCR 0017-6645	00 17 23.52	-66 45 12.5	M3.0 Ve	-4.8 ± 5.6	+11.4 ± 0.8	1
	GJ 2006A	00 27 50.24	-32 33 06.1	M3.5 Ve	-24.9 ± 4.6	...	...
	GJ 2006B	00 27 50.36	-32 33 23.9	M3.5 Ve	+6.9 ± 6.1	...	...
	HIP 003556	00 45 28.15	-51 37 34.0	M1.5 Ve	-0.7 ± 4.9	-1.6 ± 20	1
	SCR 0106-6346	01 06 22.67	-63 46 39.1	M3.0 Ve	+13.3 ± 5.2	...	...
	[PS78] 190	01 22 44.04	-25 47 07.8	M3.0 Ve	+3.6 ± 5.4	...	...
	BAR 161-12	01 35 13.94	-07 12 51.8	M4.0 Ve	+19.0 ± 5.8	+11.7 ± 5.3	2
	GIC 138	01 35 56.45	-13 25 47.3	M1.5 Ve	-26.4 ± 7.2	...	...
	L 173-39	01 48 26.17	-56 58 41.5	M1.5 Ve	+33.6 ± 5.5	...	...
	SCR 0149-5411	01 49 05.92	-54 11 57.2	M1.0 Ve	+2.1 ± 4.1	...	...
X	SCR 0152-5950	01 52 18.31	-59 50 16.8	M2.0 Ve	+14.0 ± 5.3	+7.9 ± 1.6	1
	SCR 0212-5851	02 12 58.20	-58 51 18.2	M2.0 Ve	+4.5 ± 5.0	+9.1 ± 0.8	3
	SCR 0213-4654	02 13 30.22	-46 54 50.5	M3.0 Ve	+9.4 ± 6.0	+14.3 ± 2.0	4
	SCR 0215-0929	02 15 58.93	-09 29 12.2	M2.5 Ve	+15.4 ± 5.5	+10.1 ± 0.6	3
	SCR 0220-5823	02 20 51.39	-58 23 41.1	M3.5 Ve	+18.3 ± 6.3	+12.1 ± 0.6	3
	SCR 0222-6022	02 22 44.17	-60 22 47.6	M3.5 Ve	+28.6 ± 7.0	+16.2 ± 1.5	3
C	2MASS 0236-5203	02 36 51.71	-52 03 03.7	M2.0 Ve	+12.9 ± 5.5	+16.0 ± 0.1	5
	LP 886-73	02 39 17.64	-26 49 18.9	M4.0 Ve	-16.5 ± 6.4	...	...
C	SCR 0248-3404	02 48 52.62	-34 04 24.7	M3.5 Ve	+14.5 ± 5.5	+14.6 ± 0.3	4
	SCR 0254-5746	02 54 06.31	-57 46 36.1	M2.5 V	+0.1 ± 5.0	...	...
	2MASS 0254-5108A	02 54 33.17	-51 08 31.4	M1.5 Ve	+13.0 ± 5.1	+13.8 ± 0.4	3
	SCR 0256-6343	02 56 47.09	-63 43 02.8	M4.0 Ve	-10.9 ± 6.0	+16.2 ± 3.4	4
	LP 831-35	03 10 03.07	-23 41 31.0	M3.5 Ve	+25.5 ± 6.1	...	...
	2MASS 0510-2340A	05 10 04.27	-23 40 40.7	M3.0 Ve	+18.8 ± 5.2	+24.2 ± 0.2	4
	2MASS 0510-2340B	05 10 04.88	-23 40 14.9	M2.5 Ve	+15.6 ± 7.5	+23.8 ± 0.5	4
	SCR 0522-0606	05 22 40.70	-06 06 23.9	M2.5 Ve	-1.5 ± 5.0	...	...
	SCR 0711-3510AB	07 11 59.17	-35 10 15.7	M3.0 Ve	+4.1 ± 5.0	...	...
	SCR 0844-0637	08 44 55.66	-06 37 26.0	M2.0 Ve	-18.0 ± 2.0	...	...
	LP 728-71	09 52 41.77	-15 36 13.7	M2.5 V	-5.6 ± 3.4	...	...
	SCR 1012-3124AB	10 12 09.08	-31 24 45.2	M3.5 Ve	+14.6 ± 5.5	+14.69 ± 0.53	6
	TWA 3ABCD	11 10 27.88	-37 31 52.0	M3.5 Ve	+14.5 ± 2.5	+15.6 ± 0.2	5
	SCR 1121-3845	11 21 05.49	-38 45 16.4	M1.0 Ve	+9.5 ± 2.2	+12.7 ± 1.0	5
C	TWA 5ABC	11 31 55.26	-34 36 27.3	M1.5 Ve	+10.2 ± 2.2	+12.7 ± 3.8	5
	RX 1132-3019	11 32 18.31	-30 19 51.8	M4.5 Ve	+15.8 ± 4.7	+12.3 ± 1.5	7
C	RX 1132-2651A	11 32 41.25	-26 51 55.9	M2.0 Ve	+7.8 ± 2.5	+8.68 ± 0.02	1
	SIPS 1145-4055	11 45 35.70	-40 55 57.0	M2.5 Ve	+14.2 ± 6.2	...	...
	LP 851-410	11 58 19.78	-22 40 59.7	M2.5 Ve	-36.7 ± 4.3	...	...
	SCR 1200-1731	12 00 01.60	-17 31 30.8	M3.5 Ve	+20.1 ± 2.4	...	...
X	2MASS 1207-3247	12 07 27.38	-32 47 00.3	M2.5 Ve	-16.4 ± 2.9	+8.5 ± 1.2	8
C	L 758-107	12 11 16.95	-19 58 21.7	M2.5 V	-12.0 ± 4.9	-9.226 ± 0.1	9
	SCR 1230-3300	12 30 53.02	-33 00 50.8	M1.5 Ve	+20.7 ± 2.2	...	...
	SCR 1233-3641	12 33 31.40	-36 41 40.8	M2.0 Ve	+6.7 ± 4.4	...	...
	SCR 1237-4021	12 37 12.38	-40 21 48.1	M2.5 Ve	+11.3 ± 2.4	...	...
	SCR 1238-2703	12 38 37.13	-27 03 35.0	M1.5 Ve	+0.5 ± 3.3	+9.9 ± 0.2	4
	SCR 1316-0858	13 16 40.54	-08 5825.6	M3.0 Ve	+6.1 ± 4.9	...	...
	SCR 1321-1052	13 21 56.31	-10 52 09.9	M3.5 Ve	+26.5 ± 5.6	-4.2 ± 2.2	4
	SCR 1421-0916	14 21 26.24	-09 16 58.0	M2.0 V	-4.3 ± 4.3	...	...
	SCR 1421-0755	14 21 34.06	-07 55 16.6	M3.0 V	-5.2 ± 7.2	...	...
	SCR 1425-4113AB	14 25 29.20	-41 13 32.0	M3.0 Ve	+12.4 ± 3.7	...	...
	SCR 1438-3941	14 38 36.40	-39 41 04.0	M1.5 V	+36.6 ± 5.9	...	...
	LP 914-6	14 40 22.30	-27 52 39.0	M3.0 Ve	+17.5 ± 4.1	...	...
	SCR 1521-2514	15 21 50.80	-25 14 11.0	M1.5 Ve	-0.8 ± 2.9	...	...
	SCR 1708-6936	17 08 09.00	-69 36 18.0	M3.0 Ve	+11.3 ± 3.4	+9.4 ± 3.5	4
	SCR 1816-6305	18 16 51.10	-63 05 19.0	M1.5 V	+33.5 ± 0.9	...	...
	SCR 1842-5554A	18 42 06.95	-55 54 25.5	M3.0 Ve	+9.8 ± 4.9	+0.3 ± 0.5	4
	NLTT 47004AB	18 48 41.10	-46 47 10.0	M2.5 Ve	+21.0 ± 4.0	...	...
	SCR 1856-6922	18 56 04.40	-69 21 59.0	M3.0 V	+21.1 ± 4.0	...	...
	WT 625	19 05 20.20	-54 34 40.0	M3.0 Ve	-15.6 ± 4.3	...	...
	SCR 1922-6310	19 22 50.70	-63 10 57.0	M3.0 Ve	+5.7 ± 2.1	+6.5 ± 1.6	4
C	RX 1924-3442	19 24 34.95	-34 42 39.4	M4.0 Ve	-7.7 ± 5.7	-3.7 ± 0.2	4
	SCR 1926-5331	19 26 00.75	-53 31 26.9	M4.0 Ve	-7.6 ± 6.0	...	...
	SCR 1938-2416	19 38 36.90	-24 17 00.0	M2.0 Ve	+14.4 ± 3.9	...	...
	SCR 1951-4025	19 51 35.90	-40 25 18.0	M1.5 Ve	+20.6 ± 5.9	...	...

Table 2
(Continued)

C ^a	Name	R.A. (J2000)	Decl.	Spectral Type	R.V. (km s ⁻¹)	Literature R.V.	
						(km s ⁻¹)	References
	SCR 2004-6725A	20 04 09.20	-67 25 09.0	M2.5 Ve	+10.4 ± 3.5	...	...
	2MASS 2004-3356	20 04 28.47	-33 56 10.7	M4.0 Ve	-16.1 ± 3.8	...	...
	SCR 2008-3519	20 08 53.60	-35 19 47.0	M3.0 Ve	-5.9 ± 6.3	...	...
	SCR 2010-2801AB	20 10 00.03	-28 01 41.2	M3.0 Ve	+1.0 ± 4.2	-5.8 ± 0.6	4
	L 755-19	20 28 43.40	-11 28 29.0	M1.5 Ve	-31.2 ± 5.8	...	...
	SCR 2107-7056	21 07 22.48	-70 56 12.6	M3.0 Ve	+3.3 ± 4.6	...	...
	SCR 2107-1304	21 07 36.70	-13 04 56.0	M3.0 Ve	-3.7 ± 4.8	-2.3 ± 0.5	4
	LEHPM 1-4147	21 34 52.00	-63 01 06.0	M2.5 V	+12.4 ± 4.0	...	...
	SCR 2204-0711 ^b	22 04 39.83	-07 11 33.7	...	-204.9 ± 12.1	...	...
	SCR 2237-2622	22 37 14.95	-26 22 33.3	M3.5 Ve	+3.4 ± 5.0	...	...
C	SIPS 2258-1104	22 58 16.44	-11 04 17.1	M3.0 Ve	+20.2 ± 5.5	+16.0 ± 0.2	2
	LEHPM 1-5404	23 01 49.48	-53 17 07.7	M2.0 V	+12.3 ± 6.7	...	...
	SCR 2328-6802	23 28 57.64	-68 02 33.9	M2.5 Ve	+3.5 ± 5.1	+8.0 ± 1.5	3
C	LTT 9582	23 32 00.19	-39 17 36.9	M3.0 Ve	+8.7 ± 5.3	+11.6 ± 0.7	1
	G 275-71	23 35 48.75	-24 19 09.3	M2.5 V	-2.9 ± 7.7	...	...
	LEHPM 1-6053	23 40 23.85	-40 21 47.1	M2.0 Ve	+25.2 ± 5.7	...	...

Notes. Literature RV sources: (1) Malo et al. (2013), (2) Shkolnik et al. (2012), (3) Kraus et al. (2014), (4) Malo et al. (2014), (5) Torres et al. (2006), (6) Riedel et al. (2014), (7)Looper et al. (2010), (8) Schneider et al. (2012), (9) Nidever et al. (2002).

^a Stars are noted as “C” if their spectra were used as comparisons for the RV fitting, and “X” if they were rejected as comparisons.

^b Giant; see Section 6.9.

(This table is available in machine-readable form.)

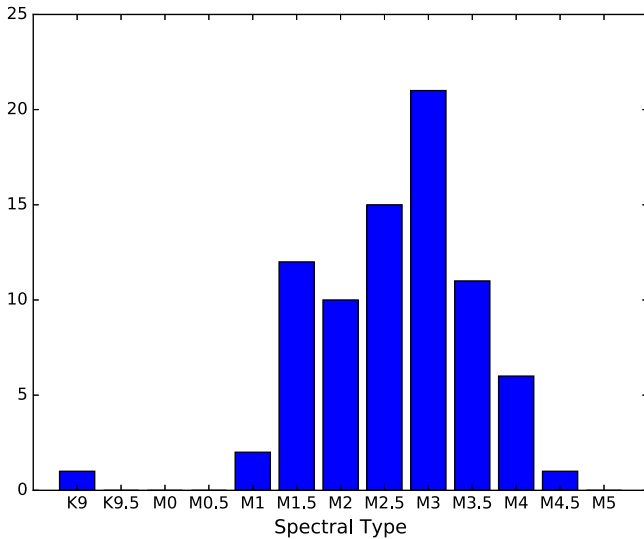


Figure 1. Distribution of spectral types of objects in the sample.

about interesting objects and trends in these line measurements, see Section 6.

5. Results

5.1. H α (6563 Å) Activity Indicator

H α emission, while related to youth, is not a reliable indicator of youth for M dwarfs as their activity can persist for billions of years. As shown by West et al. (2008), M0-M2 stars with H α emission are typically younger than 1 Gyr; M3 stars are generally less than 2 Gyr old, suggesting most of our stars are younger than field age. Checking the T Tauri veiling limit in H α EW from White & Basri (2003) suggests that none of the stars in this sample are potential T Tauri stars, which should be expected from the relative rarity of such objects within 100 pc,

although RX 1924-3442 and TWA 3ABCD come close (Figure 6) with H α emission strengths greater than -10 Å , which are recorded in Table 5.

5.2. Lithium (6708 Å) Age Indicator

Only 10 objects had measurable lithium, with a typical measurement precision of 0.18 Å . This is expected, given that the selection consists of stars close to the convective limit where lithium is fused very quickly (see Figure 7, where they are plotted against lithium-bearing stars from the Catalog of Nearby Suspected Young Stars from Riedel et al. 2016). With only three exceptions (a Tuc-Hor member and two stars that do not match any known groups), our 10 lithium-detected stars are known or new members of the $\sim 12 \text{ Myr}$ old TW Hydra moving group, as outlined in Table 5. To define typical values for the groups, we computed a 15-element moving average and a 15-element moving standard deviation for each group, such that the value (and standard deviation) of each point on the curves are the average of the surrounding 15 points, and are given for the mean $V - K$ values of those 15 points. Interestingly, all of our detections lie below the curve for TW Hya members ($\sim 10 \text{ Myr}$) and above the curve for $\beta \text{ Pic}$ ($\sim 25 \text{ Myr}$). Our targets have among the lowest lithium EWs measured for TW Hydra and the highest lithium EW for a Tuc-Hor member which suggests our unidentified young stars are under 25 Myr old. This is not entirely unexpected given the apparent spread in lithium measurements shown in Figure 7.

5.3. Potassium (7699 Å) Gravity Indicator

The potassium 7699 Å line¹³ was measured for the entire sample, and results are shown in Figure 8. In order to determine a standard of youth, the potassium EW measurements are

¹³ The other line in the doublet, potassium 7635 Å, is within the atmospheric A band and not suitable for measurement.

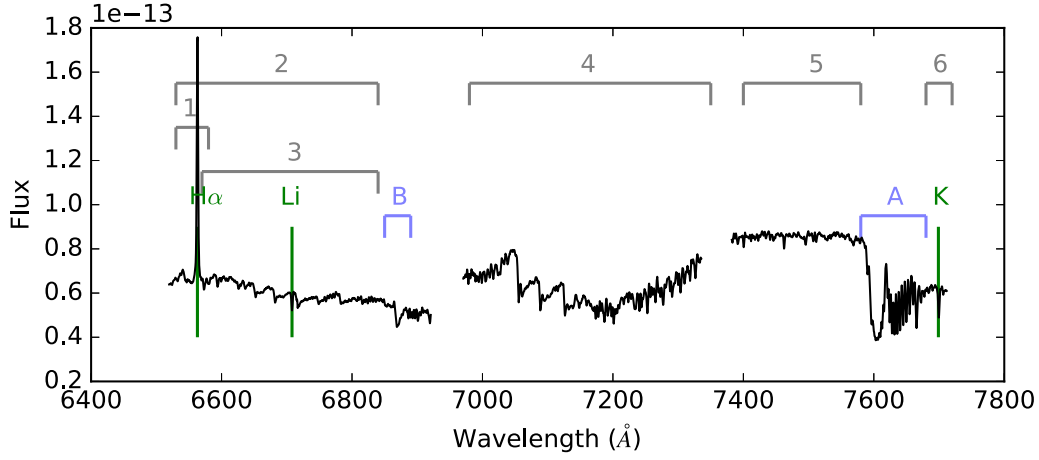


Figure 2. Spectrum of RXJ 1132-2651A (TWA 8A) showing the spectral regions considered for RV fits, the spectral lines measured, and the regions used for the telluric correction to the atmospheric A and B bands.

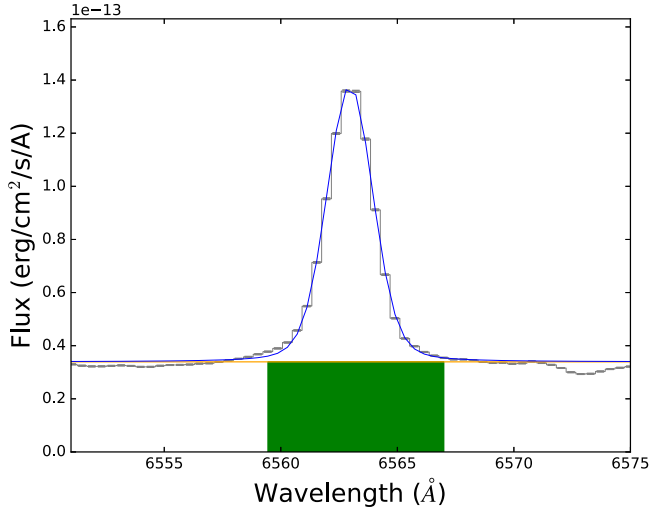


Figure 3. H α (6563 Å) EW of RX 1132-2651A (TWA 8A) as an example. The pseudocontinuum (yellow) and Voigt profile (blue) are fit to the observed spectrum (gray). The green rectangle approximates the EW.

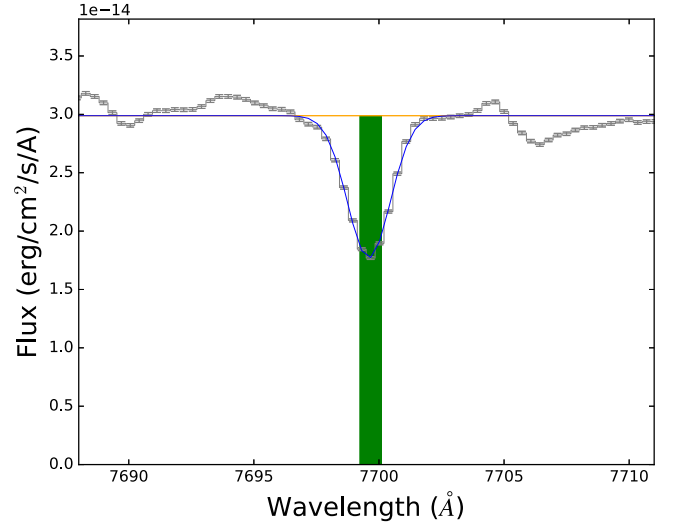


Figure 5. K I (7699 Å) EW of RX 1132-2651A (TWA 8A) as an example. The EW itself is approximated by the green rectangle. A Voigt profile and pseudocontinuum fit are shown as in Figures 3 and 4.

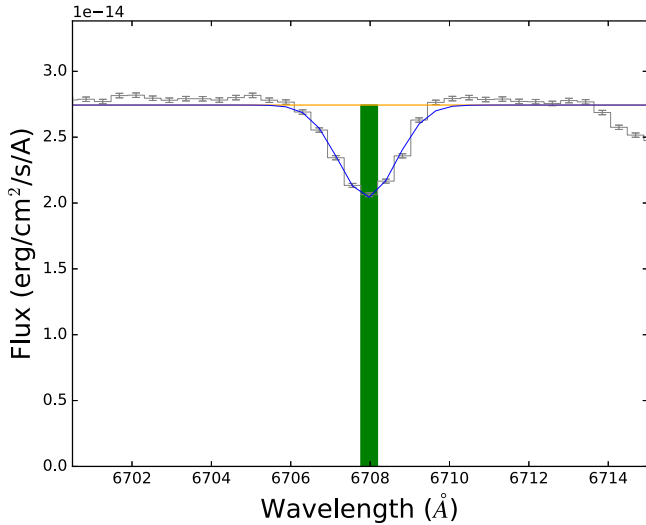


Figure 4. Li (6708 Å) EW of RX 1132-2651A (TWA 8A) as an example. The pseudocontinuum and Voigt profile are shown according to Figure 3. The green rectangle approximates the EW.

compared to measurements of objects in the Catalog of Suspected Nearby Young Stars in Riedel et al. (2016), whose potassium measurements are largely from Riedel et al. (2014) and Shkolnik et al. (2009), plus the additional field star measurements used in Riedel et al. (2014). Both samples have relatively large uncertainties on the equivalent widths (0.2 Å for Riedel et al. 2014, 0.24 or 0.16 Å for Shkolnik et al. 2009, depending on the telescope) which, combined with intrinsic scatter, make the field star locus rather large (as defined by a 15-element moving average). Stars more than one standard deviation below the main sequence locus (as defined by a 15-element moving standard deviation) in Figure 8 are therefore treated as potentially low-surface-gravity objects and likely to be young, and this is used in the youth evaluation in Table 5. The lowest value, -0.07 ± 0.01 Å, for SCR 2204-0711, is not shown in Figure 8 and suggests that the star is in fact a giant.

5.4. Kinematic Results

To supplement our RVs (Table 2, Section 4.1), ICRS positions and proper motions for these objects were obtained

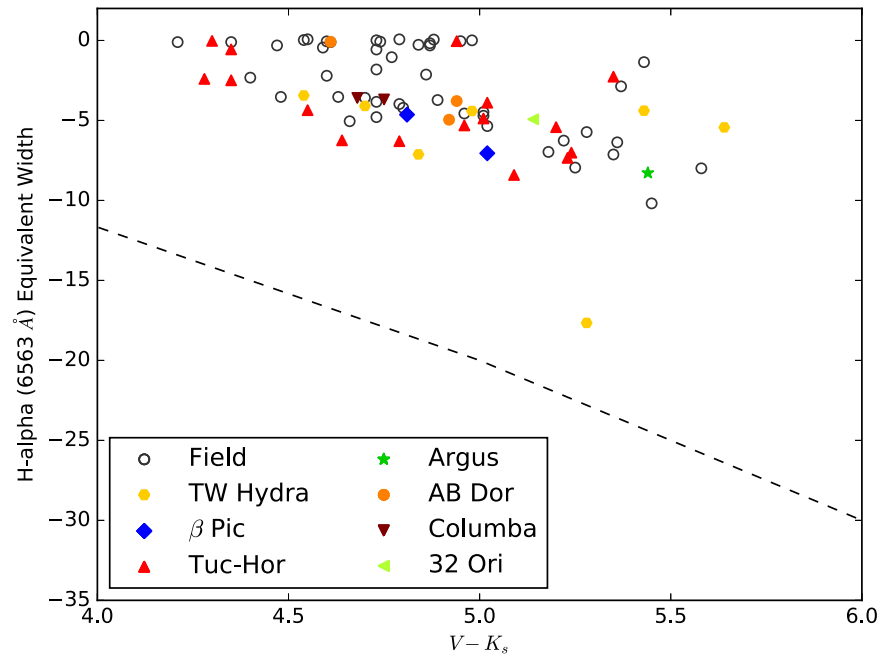


Figure 6. $H\alpha$ equivalent widths vs. $V - K$ color (as a proxy for spectral type), with veiling criterion (dashed line) from White & Basri (2003). All of these stars are post-T-Tauri stars, and the single star (represented by both measurements) that comes closest to the limit is TWA 3ABCD.

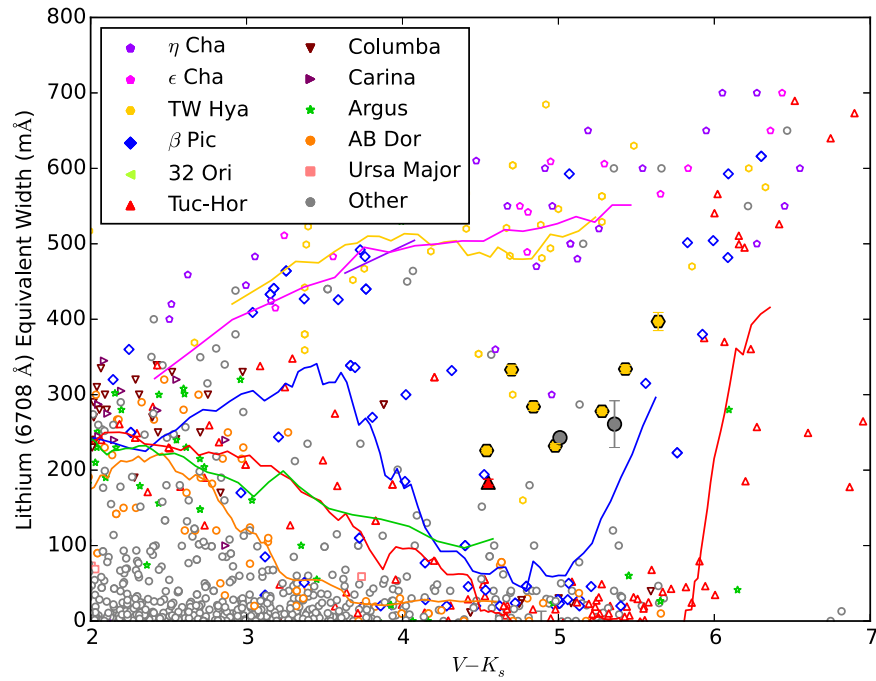


Figure 7. Lithium equivalent width vs. $V - K$. Ten stars in our sample with measurable lithium are shown with shapes outlined in black. The smaller shapes are stars from the Catalog of Suspected Nearby Young Stars (Riedel et al. 2016), with 15-element moving averages plotted as rough trend lines for each group.

from the Fourth USNO Compiled Astrographic Catalog (UCAC4, Zacharias et al. 2013) and PPMXL (Roeser et al. 2010) catalogs. These are given in Table 1.

We use the LocAtIng Constituent mEmbers In Nearby Groups (LACEwING, Riedel et al. 2016) moving group identification code to evaluate membership probabilities in the NYMGs. LACEwING calculates up to four metrics of membership by comparing the proper motions, parallaxes, RVs, and space positions of targets (depending on what data is available) against predictions computed for a member of the group at that R.A. and decl. These metrics are combined into a

single goodness-of-fit value, and translated into a membership probability using the pre-calculated results of a simulation of 8 million stars.

Membership probabilities are calculated by taking the simulated stars and matching them to each of 13 NYMGs and three open clusters (Table 3), and then computing a membership probability based on the result of combining four goodness-of-fit scores. Therefore, for a group X, there is a histogram of all the simulated stars with their goodness-of-fit scores when matched to group X. The histogram records the percentage of stars in each bin that were actually members of

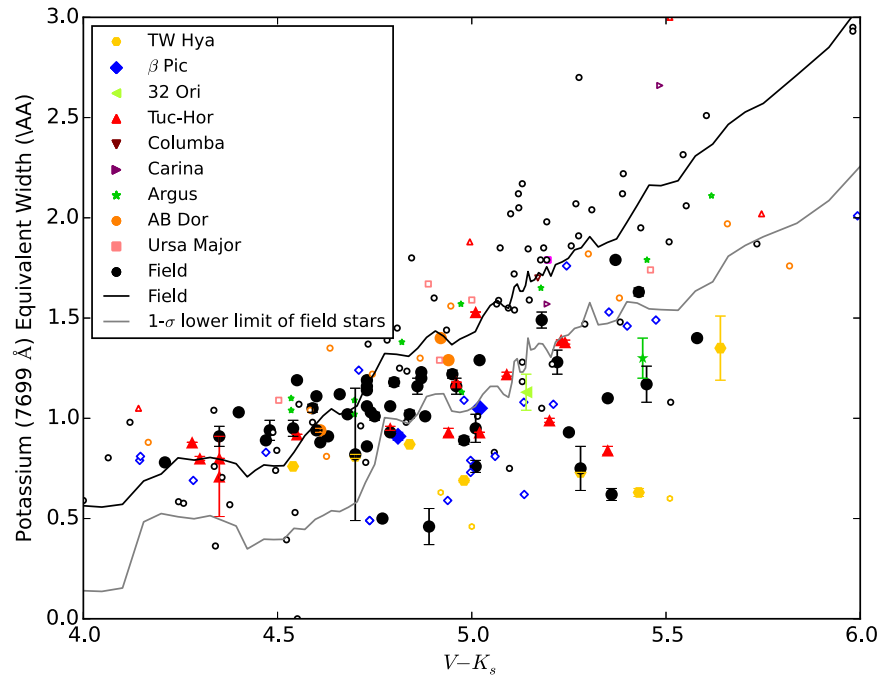


Figure 8. Potassium equivalent width vs. $V - K_s$. Stars appear according to Figure 7. The black curve is a 15-element windowed average fit to the field stars from the Catalog of Nearby Young Stars (Riedel et al. 2016) and the sample field stars in Riedel et al. (2014). The main-sequence locus has some width due to imprecise measurements in the CTIO 1.5 m RSpec data from Riedel et al. (2014) and intrinsic scatter among group members. The gray line represents the 15-element windowed standard deviation of field stars and is roughly 0.5 Å. Stars that lie below the line (i.e., with weaker potassium absorption) are considered young.

Table 3

Moving Groups and Open Clusters Considered by the LACEwING Code

Name	Age (Myr)	References
ϵ Chameleontis	5	Murphy et al. (2013)
η Chameleontis ^a	10	Murphy et al. (2013)
TW Hydra	10	Weinberger et al. (2013)
32 Orionis	20	Bell et al. (2015)
β Pictoris	25	Bell et al. (2015)
Octans	40	Murphy & Lawson (2015)
Tucana-Horologium	45	Bell et al. (2015)
Columba	45	Bell et al. (2015)
Carina	45	Bell et al. (2015)
Argus	50	Barrado Navascués et al. (2004)
AB Doradus	150	Bell et al. (2015)
Carina-Near	200	Zuckerman et al. (2006)
Ursa Major	400	Jones et al. (2015)
Coma Berenices ^a	400	Kraus & Hillenbrand (2007)
χ^1 Fornax	525	Pöhl & Paunzen (2010)
Hyades ^a	800	Brandt & Huang (2015)

Note. Ages have been rounded to the nearest 5 Myr.

^a Open cluster.

group X, effectively making the LACEwING percentages contamination probabilities. LACEwING does not force all probabilities to add up to 100%, so there is still a chance that the stars will not match any known group, or add up to more than 100% if the uncertainties are larger than the simulation expected.

As shown in Riedel et al. (2016), kinematic identification of young stars improves with more and higher-precision data. By including RVs, we significantly decrease the false positive rate. However, because LACEwING uses standard deviations in its four membership metrics, the lower quality of RVs (5 km s^{-1})

compared to the ones for which LACEwING is calibrated (1 km s^{-1}) will result in better apparent matches and higher membership probabilities than would otherwise be expected.

LACEwING has two modes. One includes a field-star population 50 times the size of the NYMG population, implicitly assuming that the star under consideration might be a field interloper with coincidentally similar motions. The other is for use if the star is already known to be young, where nearly all of the field star population is removed from consideration, leaving only a 1:1 contribution of field stars: NYMG members to represent the fact that Riedel et al. (2016) found half of all young stars (there defined as lithium-rich objects) were not members of any NYMG (see also Section 7), suggesting the presence of a young field. Stars with lithium detections or with potassium line strengths more than 1σ weaker than those of field stars were assumed to be young. All other stars were run through LACEwING’s field-star mode.

For 13 stars with parallaxes (mostly from Riedel et al. 2014), we can also compute full UVW space velocities and space positions following the matrix method of Johnson & Soderblom (1987). These are given in Table 4.

6. Discussion

Our spectroscopic indicators are only sensitive to the youngest stars in this sample of hot M dwarfs. As shown in Figure 7, we should only expect to detect significant lithium in members of the youngest groups: ϵ Cha (5 Myr), the η Cha open cluster (8 Myr), and TW Hya (10 Myr); our sample spans a range of temperatures where lithium is destroyed very quickly. None of our stars are young enough to meet the $\text{H}\alpha$ EW veiling criterion (Figure 6); all are post-T-Tauri stars. The relatively low precision of our potassium line measurements (Figure 8) demonstrates that Tuc-Hor (45 Myr) is the oldest group for which significant numbers of stars fall below the field

Table 4
UVWXYZ Space Velocities and Positions

Name	U (km s ⁻¹)	V (km s ⁻¹)	W (km s ⁻¹)	X (pc)	Y (pc)	Z (pc)
SCR 0017-6645	-17.7 ± 2.5	-8.8 ± 3.0	2.9 ± 4.3	15.6 ± 1.1	-19.8 ± 1.4	-30.1 ± 2.1
GJ 2006A	-11.6 ± 0.8	-14.9 ± 1.0	24.1 ± 4.6	4.1 ± 0.2	-1.1 ± 0.1	-32.1 ± 1.8
GJ 2006B	-12.2 ± 1.3	-13.4 ± 1.2	-8.0 ± 6.1	4.1 ± 0.2	-1.1 ± 0.1	-32.1 ± 1.8
HIP 3556	-11.3 ± 1.7	-18.7 ± 2.7	4.8 ± 4.5	9.8 ± 1.1	-13.9 ± 1.5	-37.2 ± 4.1
BAR 161-12	-13.0 ± 2.0	-9.8 ± 1.1	-17.7 ± 5.3	-10.1 ± 0.1	5.2 ± 0.0	-27.4 ± 0.2
SCR 1012-3124AB	-14.7 ± 1.4	-17.8 ± 5.2	-7.8 ± 2.3	-2.4 ± 0.2	-51.0 ± 4.9	18.8 ± 1.8
SCR 1121-3845	-13.9 ± 1.0	-16.6 ± 2.0	-6.7 ± 1.0	14.8 ± 0.7	-58.2 ± 2.6	22.8 ± 1.0
TWA 5ABC	-11.9 ± 0.7	-17.7 ± 1.9	-5.9 ± 1.0	11.6 ± 0.4	-43.8 ± 1.5	21.6 ± 0.8
RX 1132-2651A	-14.7 ± 1.6	-17.9 ± 2.2	-8.1 ± 1.9	8.2 ± 0.4	-38.7 ± 1.9	25.5 ± 1.2
2MASS 1207-3247	-18.4 ± 1.1	2.1 ± 2.4	-17.5 ± 1.5	17.9 ± 0.5	-43.6 ± 1.1	26.3 ± 0.7
SCR 1425-4113AB	-0.9 ± 2.9	-24.5 ± 2.5	-4.6 ± 1.4	49.8 ± 3.2	-39.9 ± 2.6	21.1 ± 1.4
SCR 2010-2801AB	-2.6 ± 3.6	-11.7 ± 1.3	-12.0 ± 2.2	41.0 ± 2.7	10.3 ± 0.7	-23.0 ± 1.5
L 755-19	-28.9 ± 4.4	-20.7 ± 2.9	-1.1 ± 2.7	14.0 ± 0.4	9.2 ± 0.3	-8.5 ± 0.3

Note. All values computed using right-handed coordinates, where U/X is toward the center of the Galaxy, V/Y is in the direction of motion, and W/Z is toward the north Galactic pole. Memberships for stars are given in Table 5.

(This table is available in machine-readable form.)

distribution. Any star that meets any of the spectroscopic criteria for youth is therefore definitely young, and most likely in Argus (50 Myr old) or the younger NYMGs (see Table 3). Members of older NYMGs like AB Doradus (150 Myr old) should not meet our spectroscopic young criterion. These objects may still be identified by kinematics, though it is important to reiterate that kinematic techniques make no comment on the actual age of stars.

We take the most likely group reported by the LACEwING kinematic code as the correct membership unless it is below 20% probability or the star is clearly younger than the most likely membership.

In total, we have identified 44 young systems (46 young stars) using the SALT spectroscopy, as shown in Table 5.

6.1. TW Hya Members (10 Myr)

A number of known TW Hya systems are in our sample, and we reproduce membership for all but 2MASS 1207-3247 (TWA 23), which is also our only member without a lithium detection.

We have identified one new member of TW Hya. SCR 1237-4012 (Figure 9) is confirmed by its lithium absorption, low surface gravity from potassium absorption, and kinematic match (88%) to TW Hya.

SCR 1237-4012 is only 1957 arcsec from TWA 11ABC, a triple system comprised of an A0 star, and two M2.5 companions. As an A0 star, TWA 11A is the most massive member of TW Hya. At the measured distance of TWA 11A (71.6 ± 1.4 pc, consistent with the kinematic estimate of 61 ± 10 pc), the projected separation of SCR 1237-4012 is only 0.68 pc.

Following the discussion of Mamajek et al. (2013) and Jiang & Tremaine (2010), we estimate the mass of TWA 11A at 2.3 solar masses¹⁴ and TWA 11B and C at 0.4 solar masses each based on fits to 10 Myr Baraffe & Chabrier (2010) isochrones. With a total system mass of 3 solar masses, the tidal radius should be 2 pc, and it is plausible that SCR 1237-4012 is an outer quadruple companion of the system. We note that given a

population of 38 systems, within a 1σ volume of 3000 cubic parsecs (Riedel et al. 2016), the average separation between members of TW Hya should be on the order of 2.6 pc.

If we take the proper motion of TWA 11A (pmRA, pmDEC = -56.7 ± 0.3 , -25.0 ± 0.2 mas yr⁻¹ from van Leeuwen 2007) and SCR 1237-4012 (pmRA, pmDEC = -63.7 ± 1.1 , -29.1 ± 1.1 mas yr⁻¹ from Zacharias et al. 2013), the proper motions differ by 8 mas yr⁻¹ (4σ), or 2.75 km s⁻¹ transverse velocity if they are at the same distance. There are two RVs for TWA 11: 7.1 ± 1.1 km s⁻¹ from Gontcharov (2006), and 9.4 ± 2.3 km s⁻¹ from Kharchenko et al. (2007). If we compare the RVs to our RV for SCR 1237-4012, 11.3 ± 2.4 km s⁻¹, the two systems' space velocities (if at the same distance) are separated by either 5.0 km s⁻¹ or 3.3 km s⁻¹. It is therefore somewhat less likely that the stars are in the same system, and more likely that they are either a chance alignment or that SCR 1237-4012 was ejected from the system within the past half million years.

A parallax measurement (and proper motion on a uniform system) of SCR 1237-4012 will do a great deal to determine if the 3D separation and space motion of SCR 1237-4012 is reasonable to make it a genuine companion to TWA 11A.

6.2. 32 Ori Member (20 Myr)

The 32 Orionis moving group is relatively unstudied, and currently has only 17 known or suspected members. We have found another potential member, SCR 0522-0606, a low-surface-gravity M dwarf based on its potassium EW. The RV is a 4σ mismatch with LACEwING's expectations for a member of 32 Ori, but the quality of the proper-motion agreement and resulting estimated spatial position still gives the star a 59% probability of membership.

With SCR 0522-0606's M2.5Ve spectral type, only three known members of the group have lower masses: two M3V stars, 2MASS J05253253+0625336 and 2MASS J05194398+0535021 (Bell et al. 2015), and one L1 low-gravity brown dwarf (Burgasser et al. 2016). This is thus a useful benchmark object for the lower-mass end of the system.

¹⁴ Based on <http://www.pas.rochester.edu/~emamajek/spt/AOV.txt>, checked 2016 September 20.

Table 5
Youth Properties

Name	Youth Flags	Literature		LACEwING		Kine. Dist (pc)	Kine. RV (km s ⁻¹)	Measured RV (km s ⁻¹)
		Membership	References	Membership	Prob.			
SCR 0017-6645	K	β Pic	1	Tuc-Hor	50	48.2 \pm 4.5	+7.4 \pm 3.5	-4.8 \pm 5.6
GJ 2006A	K	β Pic	2	β Pic ^a	0	35.8 \pm 3.3	+8.3 \pm 1.7	-24.9 \pm 4.6
GJ 2006B	K	β Pic	2	β Pic	49	34.3 \pm 3.2	+8.3 \pm 1.6	+6.9 \pm 6.1
HIP 3556	...	Tuc-Hor	3	Tuc-Hor	74	40.8 \pm 3.8	+5.7 \pm 3.4	-0.7 \pm 4.9
SCR 0106-6346	...	...	...	Tuc-Hor	25	39.2 \pm 4.9	+8.7 \pm 3.5	+13.3 \pm 5.2
[PS78] 190	...	...	...	...	...	...	...	+3.6 \pm 5.4
BAR 161-12	K	β Pic	4	...	...	...	...	+19.0 \pm 5.8
GIC 138	...	...	...	...	...	...	...	-26.4 \pm 7.2
L 173-39	...	...	...	...	...	...	...	+33.6 \pm 5.5
SCR 0149-5411	...	...	...	Tuc-Hor	22	37.1 \pm 4.9	+9.4 \pm 3.3	+2.1 \pm 4.1
SCR 0152-5950	...	Tuc-Hor	5	Tuc-Hor	38	39.1 \pm 5.5	+10.1 \pm 3.3	+14.0 \pm 5.3
SCR 0212-5851	...	Tuc-Hor	6	...	...	...	...	+4.5 \pm 5.0
SCR 0213-4654	...	...	...	...	...	...	...	+9.4 \pm 6.0
SCR 0215-0929	...	Tuc-Hor	1	...	...	...	...	+15.4 \pm 5.5
SCR 0220-5823	...	Tuc-Hor	6	Tuc-Hor	27	43.4 \pm 6.8	+11.3 \pm 3.3	+18.3 \pm 6.3
SCR 0222-6022	K	Tuc-Hor	6	Tuc-Hor ^a	42	30.7 \pm 4.9	+11.5 \pm 3.3	+28.6 \pm 7.0
2MASS 0236-5203	L	Tuc-Hor	7	Tuc-Hor	95	41.8 \pm 6.3	+11.7 \pm 3.1	+12.9 \pm 5.5
LP 886-73	K	...	...	...	...	...	...	-16.5 \pm 6.4
SCR 0248-3404	K	...	...	Tuc-Hor	87	46.2 \pm 5.4	+11.0 \pm 2.7	+14.5 \pm 5.5
SCR 0254-5746	...	...	...	...	...	...	...	+0.1 \pm 5.0
2MASS 0254-5108A	...	Tuc-Hor	7	Tuc-Hor	37	44.0 \pm 6.9	+12.6 \pm 3.1	+13.0 \pm 5.1
SCR 0256-6343	...	Tuc-Hor	8	...	...	...	...	-10.9 \pm 6.0
LP 831-35	...	...	...	AB Dor	32	27.4 \pm 0.1	+23.0 \pm 1.9	+25.5 \pm 6.1
2MASS 0510-2340A	...	Columba	1	Columba	27	50.2 \pm 4.8	+23.4 \pm 1.9	+18.8 \pm 5.2
2MASS 0510-2340B	...	Columba	1	Columba	20	58.4 \pm 5.9	+23.4 \pm 1.9	+15.6 \pm 7.5
SCR 0522-0606	K	...	...	32 Ori	59	87.6 \pm 6.5	+21.1 \pm 0.4	-1.5 \pm 5.0
SCR 0711-3510AB	...	AB Dor	1	...	...	...	...	+4.1 \pm 5.0
SCR 0844-0637	...	...	...	...	...	...	...	-18.0 \pm 2.0
LP 728-71	...	...	...	...	...	...	...	-5.6 \pm 3.4
SCR 1012-3124AB	LK	TW Hya	2	TW Hya	90	41.8 \pm 8.6	+15.7 \pm 2.3	+14.6 \pm 5.5
TWA 3ABCD	LKh	TW Hya	9	TW Hya	57	34.5 \pm 6.4	+12.6 \pm 2.2	+14.5 \pm 2.5
SCR 1121-3845	L	TW Hya	10	TW Hya	100	56.0 \pm 10.2	+12.1 \pm 2.2	+9.5 \pm 2.2
TWA 5ABC	L	TW Hya	11	TW Hya	100	47.4 \pm 8.6	+11.1 \pm 2.2	+10.2 \pm 2.2
RX 1132-3019	L	TW Hya	12	TW Hya	78	43.6 \pm 7.9	+10.7 \pm 2.1	+15.8 \pm 4.7
RX 1132-2651A	LK	TW Hya	13	TW Hya	88	38.6 \pm 7.6	+10.3 \pm 2.1	+7.8 \pm 2.5
SIPS 1145-4055	...	...	...	...	...	...	...	+14.2 \pm 6.2
LP 851-410	K	...	...	...	...	...	...	-36.7 \pm 4.3
SCR 1200-1731	LK	...	...	...	...	...	...	+20.1 \pm 2.4
2MASS 1207-3247	K	TW Hya	14	...	...	...	...	-16.4 \pm 2.9
L 758-107	K	...	...	...	...	...	...	-12.0 \pm 4.9
SCR 1230-3300	...	...	...	...	...	...	...	+20.7 \pm 2.2
SCR 1233-3641	...	...	...	...	...	...	...	+6.7 \pm 4.4
SCR 1237-4021	LK	...	...	TW Hya	88	61.4 \pm 10.6	+7.6 \pm 2.3	+11.3 \pm 2.4
SCR 1238-2703	...	AB Dor	1	...	...	...	...	+0.5 \pm 3.3
SCR 1316-0858	...	...	...	...	...	...	...	+6.1 \pm 4.9
SCR 1321-1052	K	...	...	...	...	...	...	+26.5 \pm 5.6
SCR 1421-0916	K	...	...	...	...	...	...	-4.3 \pm 4.3
SCR 1421-0755	K	...	...	...	...	...	...	-5.2 \pm 7.2
SCR 1425-4113AB	LK	TW Hya	2	...	...	...	...	+12.4 \pm 3.7
SCR 1438-3941	...	...	...	...	...	...	...	+36.6 \pm 5.9
LP 914-6	...	...	...	...	...	...	...	+17.5 \pm 4.1
SCR 1521-2514	...	...	...	...	...	...	...	-0.8 \pm 2.9
SCR 1708-6936	...	Tuc-Hor	1	...	...	...	...	+11.3 \pm 3.4
SCR 1816-6305	...	...	...	...	...	...	...	+33.5 \pm 0.9
SCR 1842-5554A	K	β Pic	1	...	...	...	...	+9.8 \pm 4.9
NLTT 47004AB	...	...	...	...	...	...	...	+21.0 \pm 4.0
SCR 1856-6922	...	...	...	...	...	...	...	+21.1 \pm 4.0
WT 625	...	...	...	...	...	...	...	-15.6 \pm 4.3
SCR 1922-6310	...	Tuc-Hor	1	...	...	...	...	+5.7 \pm 2.1
RX 1924-3442	Kh	β Pic	1	...	...	...	...	-7.7 \pm 5.7
SCR 1926-5331	K	...	...	Tuc-Hor	42	57.2 \pm 7.5	-2.8 \pm 3.9	-7.6 \pm 6.0
SCR 1938-2416	...	...	...	...	...	...	...	+14.4 \pm 3.9
SCR 1951-4025	...	...	...	...	...	...	...	+20.6 \pm 5.9

Table 5
(Continued)

Name	Youth Flags	Literature		LACEwING		Kine. Dist (pc)	Kine. RV (km s ⁻¹)	Measured RV (km s ⁻¹)
		Membership	References	Membership	Prob.			
SCR 2004-6725A	...	...	...	...	...	...	...	+10.4 ± 3.5
2MASS 2004-3356	K	β Pic	15	Argus	44	30.6 ± 0.7	-18.4 ± 1.8	-16.1 ± 3.8
SCR 2008-3519	K	...	...	Tuc-Hor	29	54.3 ± 6.6	-9.8 ± 4.0	-5.9 ± 6.3
SCR 2010-2801AB	K	β Pic	1	...	...	...	...	+1.0 ± 4.2
L 755-19	...	Argus	2	...	...	...	...	-31.2 ± 5.8
SCR 2107-7056	...	...	...	Tuc-Hor	23	50.0 ± 4.6	+4.6 ± 3.8	+3.3 ± 4.6
SCR 2107-1304	...	β Pic	1	...	...	...	...	-3.7 ± 4.8
LEHPM 1-4147	...	...	...	...	...	...	...	+12.4 ± 4.0
SCR 2204-0711	K	...	...	...	...	...	...	...
SCR 2237-2622	K	Argus	1	Tuc-Hor	33	44.8 ± 0.5	-8.2 ± 3.5	+3.4 ± 5.0
SIPS 2258-1104	...	...	...	...	...	...	...	+20.2 ± 5.5
LEHPM 1-5404	...	...	...	AB Dor	32	21.5 ± 0.2	+15.0 ± 1.9	+12.3 ± 6.7
SCR 2328-6802	...	Tuc-Hor	1	Tuc-Hor	32	49.6 ± 2.5	+6.3 ± 3.7	+3.5 ± 5.1
LTT 9582	...	AB Dor	1	AB Dor	31	23.3 ± 0.1	+12.1 ± 1.9	+8.7 ± 5.3
G 275-71	K	...	...	Tuc-Hor ^a	48	29.7 ± 0.9	-5.1 ± 3.1	-2.9 ± 7.7
LEHPM 1-6053	...	...	...	...	...	...	...	+25.2 ± 5.7

Note. Membership flags are based on spectroscopic analysis (see Section 5) and are given as follows: (K) potassium EW below standard deviation of field value, (L) detectable lithium absorption, and (h) H α emission stronger than -10 Å. Values are given in Table 6. Measured RVs are from Table 2. Membership references are to the first paper that identified the object as a member, and are (1) Malo et al. (2013), (2) Riedel et al. (2014), (3) Zuckerman et al. (2001), (4) Shkolnik et al. (2012), (5) Kiss et al. (2011), (6) Rodriguez et al. (2013), (7) Torres et al. (2000), (8) Kraus et al. (2014), (9) de la Reza et al. (1989) (10) Sterzik et al. (1999), (11) Gregorio-Hetem et al. (1992), (12) Looper et al. (2010), (13) Webb et al. (1999), (14) Song et al. (2003), (15) Gagné et al. (2015).

^a Initial match was to a different moving group; see Section 6 for details.

(This table is available in machine-readable form.)

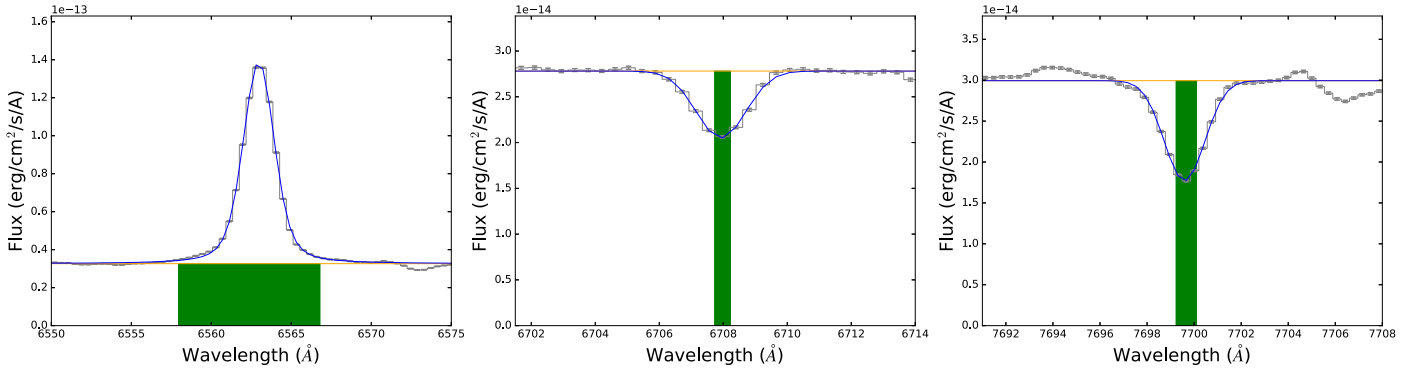


Figure 9. The measured H α (6563 Å) EW, Li (6708 Å) EW, and K I (7699 Å) EW for SCR 1237-4021. The pseudocontinuum (yellow) and Voigt profile (blue) are fit to the observed spectrum (gray). The green rectangles approximate the EWs.

6.3. β Pic Member (25 Myr)

The GJ 2006 system is a common proper motion visual binary that Riedel et al. (2014) identified as β Pic members. For unknown reasons, our RV for the A component is discrepant with both the B component and membership in β Pic, regardless of the spectral region fit or combination of comparison stars. It is not clear why this velocity is different, as both components appear to be M dwarfs with H α in emission represented here by high-SNR spectra (Figure 10); further study is needed. For our purposes, we presume this velocity is in error, and identify both objects as β Pic members in Table 5.

6.4. Tuc-Hor Members (45 Myr)

2MASS 0236-5203 was one of the first identified members of Tuc-Hor (Zuckerman et al. 2001), and we reproduce that

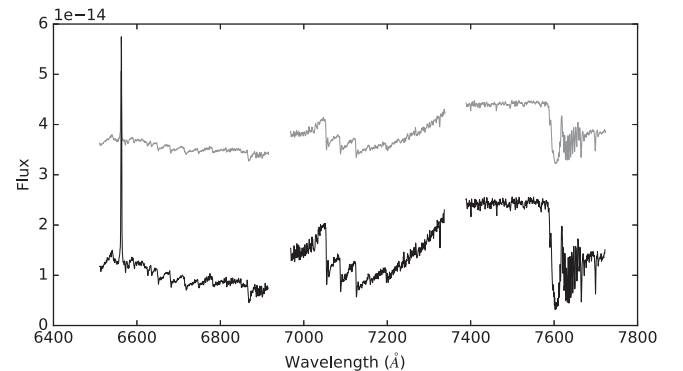


Figure 10. Spectra of GJ 2006A (top, gray) and GJ 2006B (bottom, black).

membership here. That it has a measurable lithium absorption feature is surprising given the age of Tuc-Hor, although not without precedent, as can be seen in Figure 7 and by existing

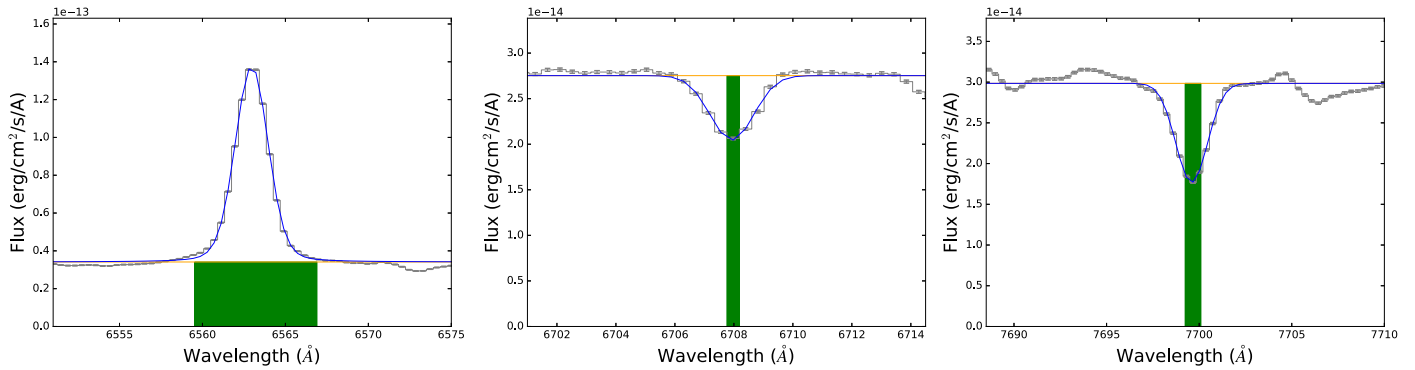


Figure 11. The measured H α (6563 Å) EW (top), Li (6708 Å) EW, and K I (7699 Å) EW for SCR 1200-1731. The pseudocontinuum (yellow) and Voigt profile (blue) are fit to the observed spectrum (gray). The green rectangles approximate the EWs.

lithium measurements of 2MASS 0236-5203 from Torres et al. (2006) and Mentuch et al. (2008). It has a 23% probability of membership in the younger β Pic moving group, but we see no concrete reason to prefer that over Tuc-Hor membership.

SCR 0222-6022 has been considered a member of Tuc-Hor before by Rodriguez et al. (2013), Kraus et al. (2014), and Malo et al. (2014). The first two papers rejected that membership. With our new RV, we find a 93% chance of membership in AB Dor, and only 42% in Tuc-Hor. However, SCR 0222-6022 has low surface gravity according to the potassium feature, which indicates it is more likely a younger star and a member of the younger Tuc-Hor NYMG.

In addition to recovering seven known members, we identify nine new members of Tuc-Hor:

SCR 0017-6645 (50%) was previously identified as a member of β Pic by Malo et al. (2013) and Riedel et al. (2014). We find only a 19% probability that it is a member of β Pic using our new RV (-4.8 ± 5.6 km s $^{-1}$). If we take a weighted mean of our RV with the RV from Malo et al. (2013) (11.4 ± 0.8 km s $^{-1}$), the star is still more likely to be a member of Tuc-Hor. Given that this was one of the stars we removed from our fitting process in Section 4.1, it may be that our RV is in error. However, if we use only Malo’s RV, the star has only a marginally higher probability (73%) of membership in β Pic than Tuc-Hor (68%).

Similarly, G 275-71 matches best to AB Dor (73%), but given its low surface gravity, it is more likely to be a member of Tuc-Hor (48%).

SCR 2237-2622 was previously identified by Malo et al. (2013) as a member of the Argus moving group. LACEwing results indicate a probability of 33% in Tuc-Hor, 32% in AB Dor, and no probability of membership in Argus.

SCR 0106-6346, SCR 0149-5411, SCR 0248-3404, SCR 1926-5331, SCR 2008-3519, and SCR 2107-7056 have never previously been identified as young stars. We note that SCR 0248-3404 was rejected as a member of Tuc-Hor by Kraus et al. (2014), and identified as an ambiguous nonmember by Malo et al. 2013; their published RVs $+23.3 \pm 0.5$ and $+14.6 \pm 0.3$ km s $^{-1}$ (respectively) differ by nearly 11σ . Malo et al. (2014) found the system to be a single-lined spectroscopic binary (SB1). Our result ($+14.5 \pm 5.5$ km s $^{-1}$) is closer to that of Malo et al. (2013).

6.5. Columba Members (45 Myr)

We find one member of the Columba moving group: 2MASS 0510-2340AB. It was identified as such by Malo et al. (2013) and we reproduce that membership for both

components. Despite being the fainter star of the pair, the B component has an earlier spectral type both here and in Malo et al. (2013). This would suggest that they are actually two separate star systems, but their proper motions, kinematic distances, and RVs are identical at the 1σ level, and they are separated by only 27 arcsec. More study of this system is needed.

6.6. Argus Members (50 Myr)

2MASS 2004-3356 was identified as an X-ray active (and therefore probably young) star by Riaz et al. (2006) and Haakonsen & Rutledge (2009), and as a member of β Pic by Gagné et al. (2015). Our RV (-16 km s $^{-1}$) is inconsistent with membership in β Pic, where -6 km s $^{-1}$ would be expected, and it has only a 14% probability of membership in β Pic according to LACEwing. With its low surface gravity and 44% probability of membership in Argus, it is the only new member of Argus we have identified in this survey.

6.7. AB Dor Members (150 Myr)

Two of the members of AB Dor identified here are new. LP 831-35 and LEHPM 1-5404 are not known as low-gravity objects, which is consistent with their age.

6.8. Young Nonmembers

Perhaps most surprisingly, 14 of our stars are young—under 50 Myr old as inferred from their potassium measurements—but are not members of any NYMG according to their kinematics.

Two of these stars have lithium detections and must therefore be very young; most likely younger than Tuc-Hor (45 Myr): SCR 1425-4113AB and SCR 1200-1731. SCR 1425-4113AB was identified by Riedel et al. (2014) as a young star with potential kinematic matches to β Pic and TW Hya. Based on its overluminosity on a color–magnitude diagram that placed it brighter than the TW Hya isochrone, it was determined more likely to be a TW Hya member despite its distance from the rest of the TW Hya members. Malo et al. (2014) disputed this, placing the system in β Pic. With our new RV, we find no probability of membership in either group, although the star remains under 25 Myr old according to its spectra. SCR 1200-1731, despite a spatial location and lithium measurement (Figure 11) that would likely make it a TW Hya member, has an RV ($+20.1$ km s $^{-1}$) that disqualifies it entirely from membership in that group.

As mentioned in Section 6.1, we did not reproduce the membership of 2MASS 1207-3247 in TW Hya. Our RV for

Table 6
SALT Equivalent Widths

Designated Name	Obs Date	H α EW (\AA)		Li EW (m \AA)		K I EW (\AA)	
		Measured	Weighted	Measured	Weighted	Measured	Weighted
SCR 0017-6645	2013 Aug 21	-6.30	-6.30 \pm 0.01	...	...	0.96	0.95 \pm 0.01
SCR 0017-6645	2013 Aug 21	-6.30	...	...	...	0.94	...
GJ 2006A	2013 Aug 18	-4.63	-4.64 \pm 0.01	...	...	0.93	0.91 \pm 0.02
GJ 2006A	2013 Aug 18	-4.65	...	...	...	0.88	...
GJ 2006B	2013 Aug 22	-7.05	-7.05 \pm 0.01	...	...	1.06	1.05 \pm 0.01
GJ 2006B	2013 Aug 22	-7.06	...	...	...	1.05	...
HIP 3556	2013 Aug 22	-0.57	-0.56 \pm 0.01	...	...	0.80	0.80 \pm 0.01
HIP 3556	2013 Aug 22	-0.54	...	...	...	0.79	...
SCR 0106-6346	2013 Aug 18	-4.90	-4.88 \pm 0.02	...	...	1.53	1.53 \pm 0.01
SCR 0106-6346	2013 Aug 18	-4.86	...	...	...	1.53	...
[PS78] 190	2013 Aug 22	-0.57	-0.57 \pm 0.01	...	...	1.18	1.19 \pm 0.01
[PS78] 190	2013 Aug 22	-0.56	...	...	...	1.20	...
BAR 161-12	2013 Aug 21	-7.56	-7.40 \pm 0.29	...	...	1.10	1.10 \pm 0.01
BAR 161-12	2013 Aug 21	-6.89	...	...	...	1.10	...
GIC 138	2014 Jan 17	+0.06	+0.08 \pm 0.01	...	...	1.20	1.17 \pm 0.01
GIC 138	2014 Jan 17	+0.08	...	...	...	1.17	...
L 173-39	2013 Aug 22	-2.33	-2.33 \pm 0.01	...	...	1.03	1.03 \pm 0.01
L 173-39	2013 Aug 22	-2.32	...	...	...	1.02	...
SCR 0149-5411	2014 Jan 18	-0.03	-0.03 \pm 0.01	...	...	0.80	0.81 \pm 0.01
SCR 0149-5411	2014 Jan 18	-0.03	...	...	...	0.81	...
SCR 0152-5950	2013 Aug 22	-2.62	-2.49 \pm 0.13	...	...	0.51	0.71 \pm 0.20
SCR 0152-5950	2013 Aug 22	-2.36	...	...	...	0.91	...
SCR 0212-5851	2013 Aug 20	-3.60	-3.54 \pm 0.06	...	...	0.88	0.92 \pm 0.05
SCR 0212-5851	2013 Aug 21	-3.47	...	...	...	0.98	...
SCR 0213-4654	2013 Dec 01	-7.23	-6.86 \pm 0.29	...	...	1.45	1.49 \pm 0.04
SCR 0213-4654	2013 Dec 01	-6.64	...	...	...	1.53	...
SCR 0215-0929	2013 Aug 23	-5.06	-5.05 \pm 0.01	...	...	1.11	1.12 \pm 0.01
SCR 0215-0929	2013 Aug 23	-5.04	...	...	...	1.13	...
SCR 0220-5823	2013 Aug 22	-8.40	-8.41 \pm 0.01	...	...	1.23	1.22 \pm 0.01
SCR 0220-5823	2013 Aug 22	-8.41	...	...	...	1.21	...
SCR 0222-6022	2013 Aug 23	-7.33	-7.34 \pm 0.01	...	...	1.39	1.39 \pm 0.01
SCR 0222-6022	2013 Aug 23	-7.35	...	...	...	1.39	...
2MASS 0236-5203	2013 Aug 22	-4.36	-4.36 \pm 0.01	180	184 \pm 4	0.92	0.92 \pm 0.01
2MASS 0236-5203	2013 Aug 22	-4.36	...	188	...	0.91	...
LP 886-73	2014 Feb 02	-7.97	-8.00 \pm 0.02	...	...	1.40	1.40 \pm 0.01
LP 886-73	2014 Feb 02	-8.02	...	...	...	1.41	...
SCR 0248-3404	2013 Aug 21	-7.36	-6.93 \pm 0.37	...	...	1.38	1.38 \pm 0.01
SCR 0248-3404	2013 Aug 21	-6.61	...	...	...	1.39	...
SCR 0254-5746	2013 Aug 21	+0.04	+0.02 \pm 0.02	...	...	0.92	0.96 \pm 0.04
SCR 0254-5746	2013 Aug 21	+0.01	...	...	...	0.99	...
2MASS 0254-5108A	2013 Aug 22	-2.47	-2.40 \pm 0.06	...	...	0.88	0.88 \pm 0.01
2MASS 0254-5108A	2013 Aug 23	-2.34	...	...	...	0.89	...
SCR 0256-6343	2013 Aug 21	-6.29	-6.26 \pm 0.03	...	...	1.22	1.28 \pm 0.06
SCR 0256-6343	2013 Aug 21	-6.24	...	...	...	1.33	...
LP 831-35	2013 Aug 23	-4.88	-4.95 \pm 0.07	...	...	1.40	1.40 \pm 0.01
LP 831-35	2013 Aug 23	-5.02	...	...	...	1.40	...
2MASS 0510-2340A	2013 Aug 23	-3.59	-3.59 \pm 0.01	...	...	1.02	1.02 \pm 0.01
2MASS 0510-2340A	2013 Aug 23	-3.59	...	...	...	1.03	...
2MASS 0510-2340B	2014 Feb 27	-3.54	...	...	...	1.01	...
2MASS 0510-2340B	2013 Oct 23	-3.84	-3.73 \pm 0.10	...	...	1.05	1.01 \pm 0.03
2MASS 0510-2340B	2013 Oct 23	-3.76	...	...	...	0.98	...
2MASS 0510-2340B	2014 Feb 27	-3.67	...	...	...	1.01	...
SCR 0522-0606	2013 Dec 02	-4.06	-5.32 \pm 0.97	...	...	1.05	1.15 \pm 0.09
SCR 0522-0606	2013 Dec 02	-6.06	...	...	...	1.23	...
SCR 0711-3510AB	2014 Apr 11	-2.11	-2.13 \pm 0.02	...	...	1.20	1.16 \pm 0.04
SCR 0711-3510AB	2014 Apr 11	-2.16	...	...	...	1.13	...
SCR 0844-0637	2014 Feb 18	-0.32	-0.31 \pm 0.01	...	...	1.20	1.20 \pm 0.01
SCR 0844-0637	2014 Feb 18	-0.30	...	...	...	1.19	...
LP 728-71	2014 Mar 08	-0.04	-0.05 \pm 0.01	...	...	1.23	1.21 \pm 0.02
LP 728-71	2014 Mar 08	-0.06	...	...	...	1.20	...
SCR 1012-3124AB	2014 Mar 15	-4.37	-4.39 \pm 0.02	329	334 \pm 5	0.61	0.63 \pm 0.02
SCR 1012-3124AB	2014 Mar 15	-4.41	...	339	...	0.64	...

Table 6
(Continued)

Designated Name	Obs Date	H α EW (Å)		Li EW (mÅ)		K I EW (Å)	
		Measured	Weighted	Measured	Weighted	Measured	Weighted
TWA 3ABCD	2014 Feb 17	-17.74	-17.66 \pm 0.08	281	278 \pm 3	0.73	0.73 \pm 0.01
TWA 3ABCD	2014 Feb 17	-17.58	...	275	...	0.73	...
SCR 1121-3845	2014 Feb 15	-3.46	-3.44 \pm 0.02	229	226 \pm 3	0.76	0.76 \pm 0.01
SCR 1121-3845	2014 Feb 15	-3.42	...	223	...	0.77	...
TWA 5ABC	2014 Feb 27	-4.20	-4.13 \pm 0.09	340	335 \pm 6	0.79	0.80 \pm 0.01
TWA 5ABC	2014 Feb 27	-4.01	...	327	...	0.82	...
RX 1132-3019	2014 Jan 30	-5.50	-5.43 \pm 0.07	409	396 \pm 12	1.51	1.34 \pm 0.16
RX 1132-3019	2014 Jan 30	-5.37	...	384	...	1.18	...
RX 1132-2651A	2014 Feb 27	-7.09	-7.12 \pm 0.03	278	283 \pm 5	0.87	0.87 \pm 0.01
RX 1132-2651A	2014 Feb 27	-7.16	...	289	...	0.87	...
SIPS 1145-4055	2013 May 25	-1.48	-1.42 \pm 0.09	...	...	1.60	1.61 \pm 0.02
SIPS 1145-4055	2013 May 25	-1.27	...	...	...	1.65	...
LP 851-410	2014 Feb 02	-2.03	-0.86 \pm 1.04	...	...	0.49	0.50 \pm 0.01
LP 851-410	2014 Feb 02	+0.06	...	...	...	0.50	...
SCR 1200-1731	2014 Jan 30	-6.47	-6.34 \pm 0.11	231	266 \pm 31	0.64	0.60 \pm 0.03
SCR 1200-1731	2014 Jan 30	-6.25	...	294	...	0.58	...
2MASS 1207-3247	2014 Feb 27	-2.83	-2.81 \pm 0.05	93	64 \pm 37	0.62	0.62 \pm 0.03
2MASS 1207-3247	2014 Feb 27	-2.79	...	22	...	0.66	...
2MASS 1207-3247	2014 Feb 27	-3.95	...	-91	...	0.41	...
2MASS 1207-3247	2014 Feb 27	-2.82	...	96	...	0.60	...
L 758-107	2014 Jan 19	+0.06	+0.06 \pm 0.01	...	...	1.02	1.01 \pm 0.01
L 758-107	2014 Jan 19	+0.05	...	...	...	1.01	...
SCR 1230-3300	2014 Jan 26	-0.33	-0.31 \pm 0.01	...	...	0.88	0.89 \pm 0.01
SCR 1230-3300	2014 Jan 26	-0.30	...	...	...	0.89	...
SCR 1233-3641	2014 Feb 02	-3.62	-3.59 \pm 0.03	...	...	0.50	0.83 \pm 0.33
SCR 1233-3641	2014 Feb 02	-3.56	...	...	...	1.15	...
SCR 1237-4021	2014 Jan 21	-4.39	-4.41 \pm 0.02	234	232 \pm 3	0.69	0.69 \pm 0.01
SCR 1237-4021	2014 Jan 21	-4.43	...	229	...	0.70	...
SCR 1238-2703	2014 Jan 14	-2.20	-2.21 \pm 0.01	...	...	1.12	1.11 \pm 0.01
SCR 1238-2703	2014 Jan 14	-2.22	...	...	...	1.10	...
SCR 1316-0858	2014 Mar 16	-2.84	-2.87 \pm 0.03	...	...	1.78	1.79 \pm 0.01
SCR 1316-0858	2014 Mar 16	-2.90	...	...	...	1.80	...
SCR 1321-1052	2014 Apr 06	-5.61	-5.72 \pm 0.11	...	...	0.86	0.75 \pm 0.11
SCR 1321-1052	2014 Apr 06	-5.84	...	...	...	0.64	...
SCR 1421-0916	2014 Mar 17	+0.08	+0.06 \pm 0.01	...	...	0.93	0.93 \pm 0.01
SCR 1421-0916	2014 Mar 17	+0.06	...	...	...	0.93	...
SCR 1421-0755	2014 Mar 15	-0.01	-0.01 \pm 0.02	...	...	0.91	0.90 \pm 0.01
SCR 1421-0755	2014 Mar 15	+0.02	...	...	...	0.88	...
SCR 1425-4113AB	2013 Apr 30	-4.76	-4.72 \pm 0.05	245	244 \pm 1	0.73	0.76 \pm 0.03
SCR 1425-4113AB	2013 Apr 30	-4.66	...	242	...	0.79	...
SCR 1438-3941	2013 Apr 30	-0.12	-0.10 \pm 0.01	...	...	0.78	0.78 \pm 0.01
SCR 1438-3941	2013 Apr 30	-0.09	...	...	...	0.79	...
LP 914-6	2013 May 01	-0.18	-0.17 \pm 0.01	...	...	1.24	1.23 \pm 0.01
LP 914-6	2013 May 01	-0.17	...	...	...	1.23	...
SCR 1521-2514	2013 May 21	-3.86	-3.84 \pm 0.02	...	...	1.06	1.06 \pm 0.01
SCR 1521-2514	2013 May 21	-3.82	...	...	...	1.06	...
SCR 1708-6936	2013 Apr 28	-4.52	-4.57 \pm 0.05	...	...	1.19	1.16 \pm 0.04
SCR 1708-6936	2013 Apr 28	-4.62	...	...	...	1.12	...
SCR 1816-6305	2013 Apr 28	-0.02	-0.11 \pm 0.08	...	...	0.85	0.91 \pm 0.05
SCR 1816-6305	2013 Apr 28	-0.20	...	...	...	0.96	...
SCR 1816-6305	2013 Apr 28	-0.10	...	...	...	0.92	...
SCR 1842-5554A	2013 Aug 20	-3.55	-5.54 \pm 1.06	...	...	0.86	0.97 \pm 0.03
SCR 1842-5554A	2013 Aug 20	-3.58	...	...	...	1.02	...
SCR 1842-5554A	2014 Mar 16	-6.38	...	...	...	0.97	...
SCR 1842-5554A	2014 Mar 16	-5.91	...	...	...	0.98	...
NLTT 47004AB	2013 Jun 18	-0.11	-0.11 \pm 0.01	...	...	0.88	0.88 \pm 0.01
NLTT 47004AB	2013 Jun 18	-0.10	...	...	...	0.87	...
SCR 1856-6922	2013 Apr 28	-0.10	-0.08 \pm 0.02	...	...	1.02	1.03 \pm 0.01
SCR 1856-6922	2013 Apr 28	-0.06	...	...	...	1.04	...
WT 625	2013 Jul 22	-3.98	-3.97 \pm 0.01	...	...	1.07	1.06 \pm 0.01
WT 625	2013 Jul 22	-3.96	...	...	...	1.06	...
SCR 1922-6310	2013 May 18	-4.83	-4.79 \pm 0.04	...	...	1.14	1.14 \pm 0.01

Table 6
(Continued)

Designated Name	Obs Date	H α EW (Å)		Li EW (mÅ)		K I EW (Å)	
		Measured	Weighted	Measured	Weighted	Measured	Weighted
SCR 1922-6310	2013 May 18	-4.75	...	...	...	1.15	...
RX 1924-3442	2013 Aug 20	-10.13	-10.18 \pm 0.05	...	...	1.08	1.17 \pm 0.09
RX 1924-3442	2013 Aug 20	-10.23	...	...	...	1.27	...
SCR 1926-5331	2013 Aug 20	-2.33	-2.27 \pm 0.06	...	...	0.86	0.83 \pm 0.02
SCR 1926-5331	2013 Aug 20	-2.21	...	...	...	0.81	...
SCR 1938-2416	2013 Jun 17	-0.46	-0.45 \pm 0.01	...	...	1.06	1.05 \pm 0.02
SCR 1938-2416	2013 Jun 17	-0.44	...	...	...	1.03	...
SCR 1951-4025	2013 Jun 16	-0.21	-0.27 \pm 0.06	...	...	1.00	1.02 \pm 0.02
SCR 1951-4025	2013 Jun 16	-0.33	...	...	...	1.04	...
SCR 2004-6725A	2013 Apr 28	-3.50	-3.55 \pm 0.04	...	...	0.91	0.91 \pm 0.01
SCR 2004-6725A	2013 Apr 28	-3.58	...	...	...	0.91	...
2MASS 2004-3356	2014 Apr 10	-8.50	-8.20 \pm 0.15	...	...	1.40	1.26 \pm 0.09
2MASS 2004-3356	2014 Apr 11	-8.16	...	...	...	1.30	...
2MASS 2004-3356	2014 Apr 11	-8.09	...	...	...	1.16	...
SCR 2008-3519	2013 Jun 16	-5.45	-5.42 \pm 0.03	...	...	0.98	0.99 \pm 0.01
SCR 2008-3519	2013 Jun 16	-5.39	...	...	...	1.00	...
SCR 2010-2801AB	2013 May 23	-7.93	-7.94 \pm 0.02	...	...	0.92	0.93 \pm 0.01
SCR 2010-2801AB	2013 May 23	-7.97	...	...	...	0.94	...
L 755-19	2013 Jun 12	-5.32	-5.35 \pm 0.03	...	...	1.29	1.29 \pm 0.01
L 755-19	2013 Jun 12	-5.38	...	...	...	1.29	...
SCR 2107-7056	2014 Jul 15	-5.29	-5.31 \pm 0.02	...	...	1.18	1.18 \pm 0.01
SCR 2107-7056	2014 Jul 15	-5.34	...	...	...	1.18	...
SCR 2107-1304	2013 Aug 22	-4.27	-4.21 \pm 0.06	...	...	1.19	1.18 \pm 0.01
SCR 2107-1304	2013 Aug 22	-4.15	...	...	...	1.16	...
LEHPM 1-4147	2013 Apr 28	+0.02	+0.01 \pm 0.01	...	...	0.86	0.86 \pm 0.01
LEHPM 1-4147	2013 Apr 28	-0.01	...	...	...	0.87	...
SCR 2204-0711	2013 Aug 23	-0.34	-0.33 \pm 0.01	...	...	-0.09	-0.07 \pm 0.01
SCR 2204-0711	2013 Aug 23	-0.32	...	...	...	-0.06	...
SCR 2237-2622	2013 Aug 18	-6.24	-6.24 \pm 0.05	...	...	1.46	1.46 \pm 0.02
SIPS 2258-1104	2013 Sep 13	-1.80	-1.82 \pm 0.01	...	...	1.16	1.16 \pm 0.01
SIPS 2258-1104	2013 Sep 13	-1.83	...	...	...	1.16	...
LEHPM 1-5404	2013 Aug 20	-0.08	-0.09 \pm 0.01	...	...	0.95	0.95 \pm 0.01
LEHPM 1-5404	2013 Aug 20	-0.09	...	...	...	0.94	...
SCR 2328-6802	2013 Aug 20	-3.89	-3.89 \pm 0.01	...	...	0.92	0.92 \pm 0.01
SCR 2328-6802	2013 Aug 20	-3.89	...	...	...	0.93	...
LTT 9582	2013 Aug 20	-3.79	-3.79 \pm 0.01	...	...	1.30	1.29 \pm 0.01
LTT 9582	2013 Aug 20	-3.79	...	...	...	1.28	...
G 275-71	2013 Nov 30	-0.06	-0.01 \pm 0.02	...	...	0.91	0.94 \pm 0.02
G 275-71	2013 Nov 30	-0.01	...	...	...	0.95	...
LEHPM 1-6053	2013 Aug 23	-0.07	-0.06 \pm 0.01	...	...	0.94	0.94 \pm 0.01
LEHPM 1-6053	2013 Aug 23	-0.04	...	...	...	0.94	...
Flux Standards							
LTT 1020	2014 Feb 05	+0.03	+0.03 \pm 0.01	...	...	-0.92	-0.92 \pm 0.02
EG 21	2013 Aug 21	+0.53	+0.40 \pm 0.30	...	...	-0.05	-0.03 \pm 0.05
EG 21	2013 Dec 01	+0.52	...	...	...	-0.14	...
EG 21	2014 Jan 17	-0.13	...	...	...	0.04	...
EG 21	2014 Jan 18	+0.64	...	...	...	0.00	...
LTT 2415	2013 Apr 30	-0.78	-0.78 \pm 0.02	...	...	-0.05	-0.05 \pm 0.02
HILTNER 600	2014 Mar 08	-0.00	-0.00 \pm 0.01	...	...	0.08	0.08 \pm 0.01
LTT 4364	2013 Jun 18	+0.01	+0.02 \pm 0.01	...	...	0.01	-0.39 \pm 0.51
LTT 4364	2013 Jun 18	+0.02	...	...	...	-1.04	...
LTT 4364	2014 Jan 14	+0.01	...	...	...	-0.02	...
HR 5501	2014 Mar 15	+0.97	+0.97 \pm 0.01	...	...	-0.01	-0.01 \pm 0.01
LTT 7987	2014 Apr 06	+0.18	+0.18 \pm 0.03	...	...	0.04	0.04 \pm 0.04

(This table is available in machine-readable form.)

2MASS 1207-3247 (-16.4 ± 2.9) is very discrepant with the previously reported RV $+8.5 \pm 1.2$ (Malo et al. 2013). If we combine that measurement with ours into a weighted mean ($+4.8 \pm 8.8$), we find a 100% probability of membership in

TW Hya. If we remove that RV, we find that the proper motions on their own are also discrepant with membership in TW Hya. It is worth noting that this was one of the stars we removed from our RV comparisons in 4.1.

BAR 161-12, SCR 1842-5554A, RX 1924-3442, and SCR 2010-2801AB have previously been identified as β Pic members, but are not members based on our new RVs. All of them (except BAR 161-12, which matches nothing) still match β Pic, though with probabilities too low to be meaningful.

L 755-19 was identified by Riedel et al. (2014) as a potential member of Argus, but with an RV it has a membership probability of only 19%.

LP 886-73, LP 851-410, L 758-107, SCR 1321-1052, SCR 1421-0755, and SCR 1421-0916 have never been suspected of membership in any moving group before, and their only claim to youth is the fact that they have low surface gravity according to our potassium measurements. While these identifications might possibly be spurious, we believe that we have demonstrated this search methodology’s ability to identify and recover genuinely young stars, and that these stars are therefore also young field stars.

6.9. Giants

The negative potassium EW (Table 6) measured for SCR 2204-0711 (as well as our H α EW and large and uncertain RV in Table 2) is actually the result of the measurement code seeking out a completely different feature. This object appears to have no measurable potassium absorption, and is likely to be a giant or supergiant, not a young star. This object has a spectral type of K9 but the colors of an M1–M6 dwarf.

7. Conclusions

We have obtained low-resolution red optical spectroscopy of 79 potentially nearby M dwarfs in 77 star systems. With that spectroscopy, we measured an age indicator, Li 6708 Å, a gravity indicator, KI 7699 Å, an activity indicator, H α 6563 Å, and 5 km s^{−1} precision RVs for every star in our sample.

Using that information, we have identified 44 young star systems: seven members of TW Hydra, one member of β Pic, one member of 32 Ori, 16 members of Tuc-Hor, one member of Columba, one member of Argus, three members of AB Dor, and 14 young systems that we cannot place among the NYMGs. By adding RVs and spectroscopic confirmation, we reinforce the strength of the membership identifications. Of the young systems, 12 are new moving group members, including one new member of TW Hya, one new member of 32 Ori, nine new members of Tuc-Hor, one new member of Argus, and two new members of AB Dor. We have also discovered one giant. This study proves that the selection cuts imposed by the TINYMO survey are extremely effective at identifying young stars, considering the ratio of field stars to young stars is 25:1 (Riedel et al. 2016) in the Solar Neighborhood.

We find that the new TW Hya member, SCR 1237-4012, is potentially within the tidal radius of the triple-star system TWA 11, and may be a fourth member or recently ejected object. We have also identified nine new members of Tuc-Hor, making the numerically largest known moving group (209 systems, Riedel et al. 2016; now 218) even larger. And we have added the third-lowest-mass member of the poorly explored 32 Ori moving group.

We also find further confirmation that a large number of young systems are not identifiably members of any known NYMGs—32% (30% if we allow for 2MASS 1207-3247 as an actual member of TW Hya) of our young star systems are not

members of any NYMG. This has been noticed before. Riedel et al. (2016) used a catalog constructed from NYMG membership papers, selected a sample of spectroscopically young (defined as having detectable lithium) and high-confidence “bona fide” members, and found that more than half of the systems were *not* members of any known NYMGs when analyzed uniformly with any publicly available moving group identification code. Our sample here is unlike the samples provided by most moving group identification papers. We did not start by kinematically identifying stars in a proper motion sample and then following up only likely candidates with spectroscopy; rather, our sample is biased only to bright, low-proper-motion objects. Given that these stars genuinely appear to be young, further work is necessary to determine the true nature of these stars.

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Software: Astropy (Astropy Collaboration et al. 2013), LACEwING (Riedel et al. 2016), MATCHSTAR (Riedel et al. 2014), PHEW (Alam & Douglas 2016), PyRAF, PySpecKit (Ginsburg & Mirocha 2011).

Facility: SALT (RSS).

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